Volume 29. DECEMBER, 1915. $3.00 a Year.
Number 4. $1.00 a Number.

JOURNAL

OF THE

New England Water Works Association.

ISSUED QUARTERLY.

PUBLISHED BY

THE NEW ENGLAND WATER WORKS ASSOCIATION,

715 Tremont Temple, Boston, Mass.

Entered as second-class matter September 23, 1903, at the Post Office at Boston, Mass., under Act of Congress of March 3, 1879.

Copyright, 1915, by the NEW ENGLAND WATER WORKS ASSOCIATION.

OFFICERS

OF THE

New England Water Works Association.

1915.

PRESIDENT.

LEONARD METCALF, Consulting Engineer, Boston, Mass.

VICE-PRESIDENTS.

JAMES BURNIE, Supt., Water Co., Biddeford, Me.
CARLETON E. DAVIS, Chief, Bureau of Water, Philadelphia, Pa.
GEORGE F. MERRILL, Supt., Water Works, Greenfield, Mass.
CALEB M. SAVILLE, Chf. Engr., Bd. Water Commissioners, Hartford, Conn.
CHARLES W. SHERMAN, Consulting Engineer, Boston, Mass.
WILLIAM F. SULLIVAN, Engr. and Supt. Pennichuck Water Works, Nashua, N. H.

SECRETARY.

WILLARD KENT, Civil Engineer, Narragansett Pier, R. I.

EDITOR.

RICHARD K. HALE, Civil Engineer, 85 Water Street, Boston, Mass.

TREASURER.

LEWIS M. BANCROFT, Supt. Water Works, Reading, Mass.

ADVERTISING AGENT.

GEORGE A. KING, Supt. Water Works, Taunton, Mass.

ADDITIONAL MEMBERS OF EXECUTIVE COMMITTEE.

EDWIN C. BROOKS, Melrose, Mass.
SAMUEL E. KILLAM, Supt. Pipe Lines and Reservoirs, Metropolitan Water Works, Boston, Mass.
GEORGE W. BATCHELDER, Water Commissioner, Worcester, Mass.

FINANCE COMMITTEE.

A. R. HATHAWAY, Water Registrar, Springfield, Mass.
GEORGE H. FINNERAN, Asst. Supt. Water Service, Boston, Mass.
ALBERT L. SAWYER, Water Registrar, Haverhill, Mass.

THE ASSOCIATION was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of over 900 men. Its membership is divided into two principal classes, viz.: MEMBERS and ASSOCIATES. Members are divided into two classes, viz.: RESIDENT and NON-RESIDENT, — the former comprising those residing within the limits of New England, while the latter class includes those residing elsewhere. The INITIATION fee for the former class is FIVE dollars; for the latter, THREE dollars. The annual dues for both classes of Active membership are THREE dollars. Associate membership is open to firms or agents of firms engaged in dealing in water works supplies. The initiation fee for Associate membership is TEN dollars, and the annual dues FIFTEEN dollars. This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.

Table of Contents.

	PAGE
The Present Status of the Catskill Water Supply for New York City. By J. Waldo Smith	481
Kensico Reservoir. By Wilson Fitch Smith	486
Sanitary Improvement of a Large Watershed. By George G. Honness	502
Electrically Operated Valve Installations and Their Control from a Distance. By Alfred Williamson	507
Pump Slip Tests as an Aid to Efficiency in the Operation of Pumping Engines. By H. T. Havill	511
Laying Water Pipes in Congested Streets, New York City. By M. Blatt	513
Control of Public Water Supplies by the Conservation Commission of the State of New York. By Russell Suter	520
The Location of Leaks in Submarine Pipe Lines. By Elmer G. Hooper	536
Testing Meters for Accuracy and Friction Loss. By Fred B. Nelson	539
The Brooklyn Water Supply. By Wm. F. Laase	546
Grubbing a Large Reservoir. By George A Winsor	554
Leadite Joints for Water Pipes. By Henry A. Symonds	557
Leadite for Joints in Cast-Iron Water Pipes. By W. C. Hawley	563
Proceedings:	
November Meeting	577
December Meeting	584
Executive Committee:	
November 10, 1915	590
December 8, 1915	591
Obituary: Dexter Brackett	592

New England Water Works Association.

ORGANIZED 1882.

Vol. XXIX. **December, 1915.** **No. 4.**

This Association, as a body, is not responsible for the statements or opinions of any of its members.

THE PRESENT STATUS OF THE CATSKILL WATER SUPPLY FOR NEW YORK CITY.

BY J. WALDO SMITH, CHIEF ENGINEER, BOARD OF WATER SUPPLY, NEW YORK CITY.

[*Read September 7, 1915.*]

Ten years ago it was my privilege to welcome the members of this Association to New York as they gathered for their annual convention some three months after the organization of the Board of Water Supply, when the engineering force numbered only twenty-five. Since that time the work has progressed to a maximum where the yearly expenditure was twenty-six million dollars, with an engineering force of about 1 320, and the time is now near when the city can utilize this great improvement. The maximum expended in any one month was $3 900 000, and the maximum amount earned on any one contract in a month was $473 000. The maximum amount earned on all contracts in a single year was $19 500 000, and there have been six years when the earnings were in excess of $10 000 000. The total expenditures to date are $127 300 000, and obligations undertaken and nearly completed for $8 300 000, or a total of $135 600 000. No contract in a total of $99 965 000 has been relet, and, so far as I can learn, no surety company has been called on to advance money. In order to furnish necessary data for the location of structures and the preparation of contracts, forty-six miles in depth of borings were made. The first construction contract for eleven miles of aqueduct was ready to advertise in October, 1906.

The present status of the work is:

The construction work of the Ashokan Reservoir is substantially completed, and there remain only grading and grassing, some highway and bridge work, the superstructures of the gate chambers and the aëration basin to be done. Water has been stored in the West Basin since September, 1913, and in the East Basin for about one year. Much water has been wasted during

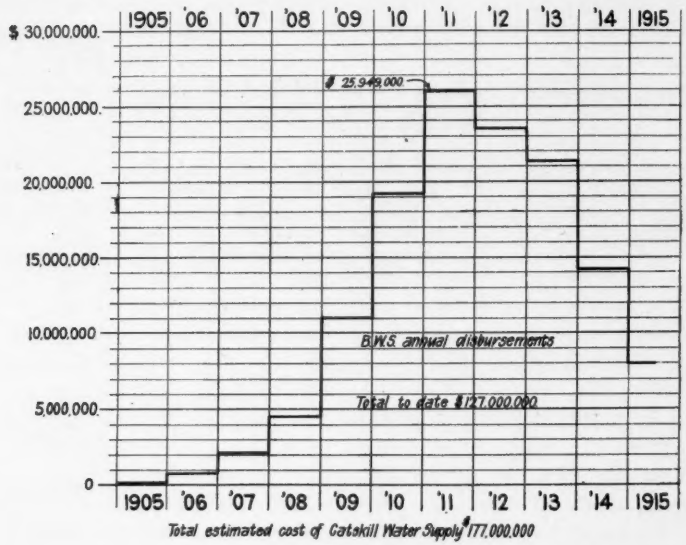


FIG. 1.

Diagram of the annual expenditures to date of the Board of Water Supply.

this year and there is still in store about 80 billion gallons of a total of 128 billion gallons. This reservoir will furnish a daily supply of not less than 250 million gallons, and investigations are now under way for other reservoirs to increase the capacity to not less than 600 million gallons per day. The capacity of this reservoir is over 20 per cent. greater than that of all the reservoirs in the Croton watershed. The construction work on the aqueduct, 92 miles long, will be completed in October, and more

FIG. 1.

The site of the Ashokan Dam as it existed ten years ago, the location of the dam being at the left of the picture, around the bend.

FIG. 2.

The Ashokan Dam as it exists to-day. This picture is taken very nearly from the same point as Fig. 1.

than half of it has been carefully tested. Recent hydraulic experiments have disclosed that its capacity, making a reasonable allowance for loss due to growths which may accumulate in years of use, is about 600 million gallons per day. Recent measurements of leakage of two of the principal pressure tunnels, the Rondout and Wallkill, each 4½ miles long, showed for the Rondout, with 230 ft. unbalanced head or outward pressure, 70 gal. per minute, and for the Wallkill, with 150 ft. outward pressure, 32 gal. per minute. A preliminary test of 3½ miles of the city

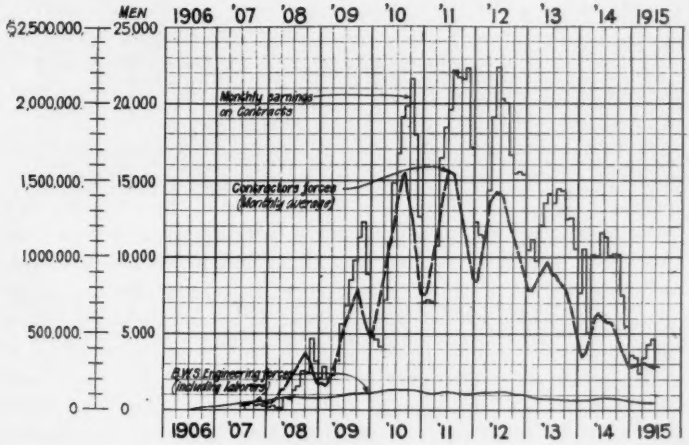


FIG. 2.

This diagram shows the maximum monthly earnings by contractors, reaching the maximum of about $2 200 000 in 1911; the contractors' working force, reaching a maximum of about 17 000; and the engineering force, at the bottom, which reaches a maximum of about 1 325.

pressure tunnel between 93d Street and 25th Street, with 250 ft. outward pressure, showed a leakage of 90 gal. per minute, and if this follows the example of the other similar tunnels, will show a substantial reduction with time.

Construction work of the Kensico Reservoir will be so far completed at the end of the year that it may be entirely filled about four years ahead of the contract time.

The construction work of Hill View Reservoir, a small equalizing reservoir at the entrance of the city pressure tunnel, will be completed in October. The construction work of the city pressure tunnel, 18.1 miles long, the longest tunnel in the world, and varying in finished diameter from 15 to 11 ft., is nearing completion. The tunnel proper is completed, with the exception of tests. There remains, however, much detailed work in and at the top of shafts connecting it with the distribution system. The submerged pipe line across the Narrows promises completion by the end of the year, and the reservoir on Staten Island is in an advanced stage of construction.

For the 6.3 miles of steel pipe siphon, only one pipe has been laid; the other two will be added when the reservoir capacity is increased. Studies for a filtration plant are now under way, but, if built, this cannot be completed before 1920.

Since the Association met here in 1905, the work has progressed without misadventure or serious accident, so it is confidently expected that by January 1, 1916, it will be in the condition of a very large machine with very many working parts, which have just been assembled for the first time, and which has not been adjusted or tested. Some of the parts of the machine are necessarily of new and untried design to satisfy conditions never before met. And the problem that will then confront us on January 1, 1916, is the adjustment and test of this machine, the smoothing of the gears and bearings, the replacement or modification of the parts which do not properly perform their functions, the training of the operating force, the thorough adjustment and trial of the entire plant, and the tuning up and synchronizing of all the working parts, to the end that the operation may be safe, smooth, and continuous. It is believed that this may require all of the year 1916, although undoubtedly at times water from the Catskills will be delivered into the distribution system.

When it is considered that a considerable part of the total supply will be delivered directly into the pipes without any intervening reservoir and that a pumped supply of about 200 million gallons daily will be discontinued and the men laid off, it will be realized that everything in connection with the gravity supply

FIG. 1.

One of the bridges, this particular one being the Traver Hollow Bridge on Ashokan Reservoir road system.

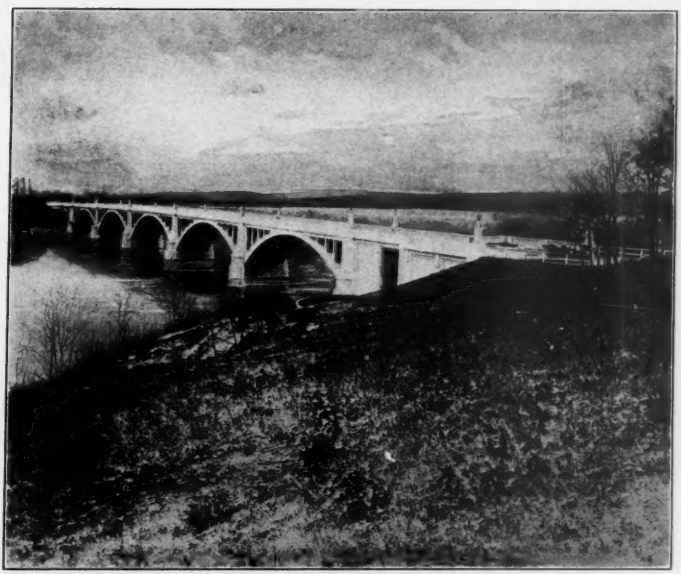


FIG. 2.

Another bridge carrying a state highway across the Kensico Reservoir.

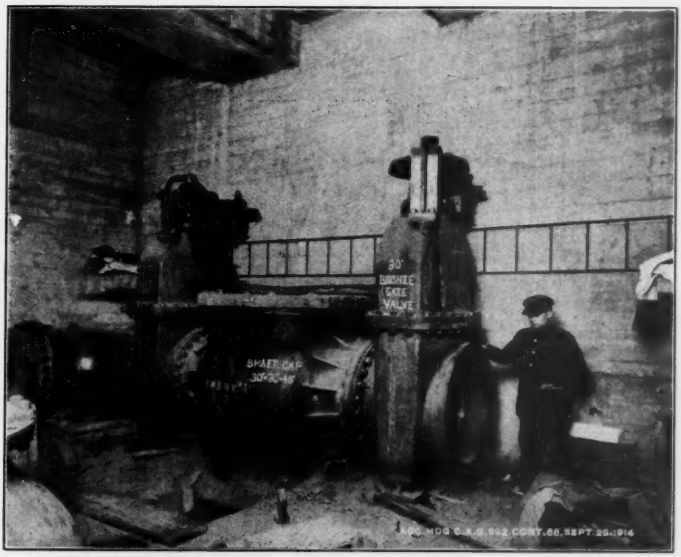


FIG. 1. This picture shows one of the risers which comes up through a shaft of the city tunnel, the view being of the inside of one of the chambers. The shaft cap and valves on either side are of solid bronze, and the cap is riveted directly to the riser pipe which comes up the shaft. On either side connections will be made to the distribution system.

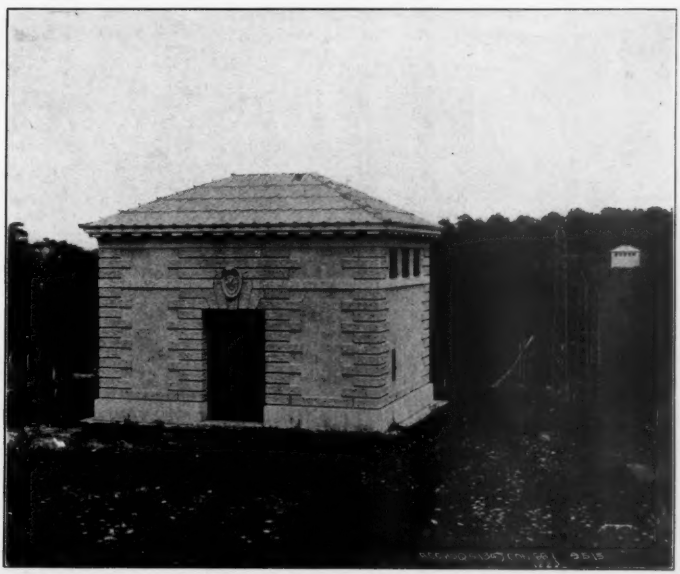


FIG. 2. A completed siphon chamber. There is such a chamber at each end of each steel pipe siphon. In the distance you see the downstream chamber for the same siphon.

must be made as perfect and safe as possible, and that the estimated time of a year is none too long.

When the work is so far completed that water can safely and continuously be delivered to the distribution system, the maintenance and operation of that portion will devolve on and be directed by the Department of Water Supply.

KENSICO RESERVOIR.

BY WILSON FITCH SMITH, DIVISION ENGINEER, BOARD OF WATER SUPPLY, NEW YORK CITY.

[*Read September 8, 1915.*]

The Kensico Reservoir is an important feature of the Catskill Aqueduct project. It is located in the upper valley of the Bronx River in Westchester County, about three miles north of White Plains, and will form a storage reservoir comparatively near the city for the Catskill water collected in the impounding reservoirs, of which the Ashokan is the first to be constructed.

Kensico Reservoir is formed by Kensico Dam. The storage behind Kensico Dam will cover 2 218 acres at Elev. 355 above mean sea level, with a maximum depth of 155 ft., an average depth of 53 ft., and an available capacity of 29 000 000 000 gal. This will afford a large reserve storage near the city, only fourteen miles above the distributing reservoir at Hill View just north of the city line, and will make possible the closing down for inspection and repair if necessary the seventy-five miles of aqueduct between Kensico and Ashokan. As the city already maintained a reservoir at this point, it owned 1 300 acres, including the Rye Ponds, and about 3 200 acres of additional land were acquired for the purpose of the new reservoir. The old reservoir supplied a portion of the Bronx Borough with about 18 000 000 gal. a day through a 48-in. cast-iron pipe line, and as the selected site for the new dam was about 400 ft. above the old dam, it was necessary to provide a substitute supply during the construction of the new dam. Therefore, the first work was the construction of the temporary reservoir further up in the Bronx Valley, and the pipe line connecting it with the Bronx conduit.

The Catskill Aqueduct, with a maximum daily capacity of 500 000 000 gal., will discharge into the upper end of Kensico Reservoir four miles north of the dam over a weir 216 ft. long in the side of the aqueduct. The hydraulic grade line of the aque-

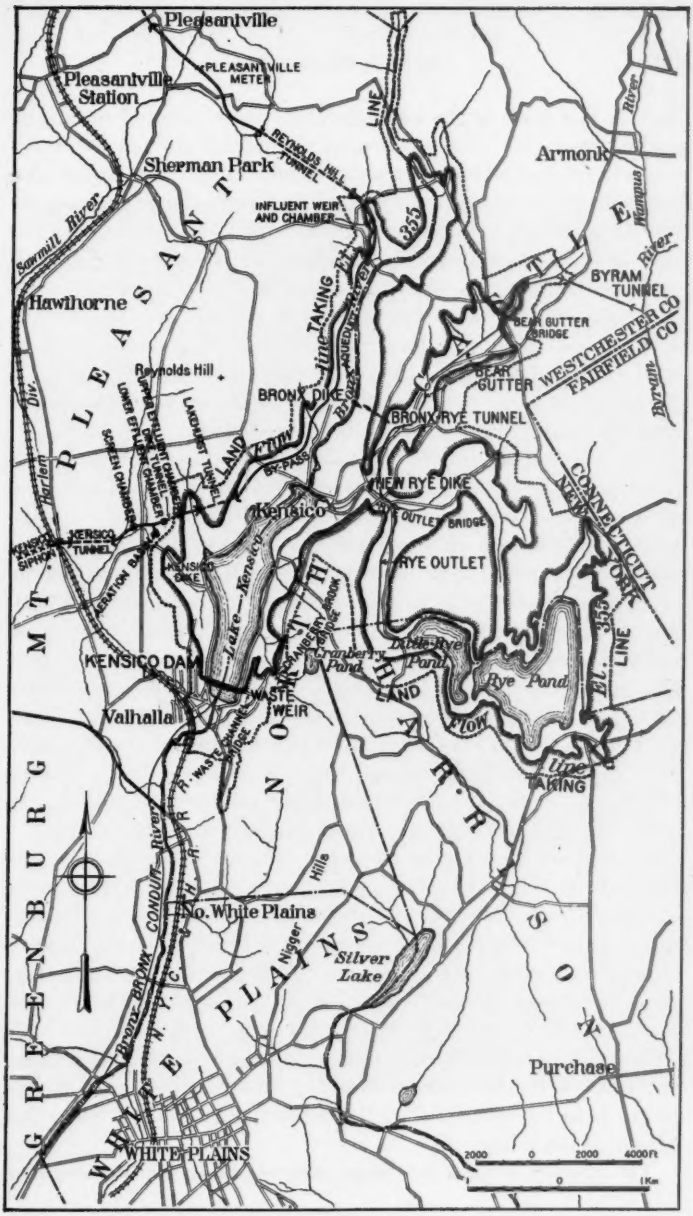

Pleasantville
Pleasantville Station
PLEASANTVILLE METER
REYNOLDS HILL TUNNEL
Sherman Park
INFLUENT WEIR AND CHAMBER
Sawmill River
Hawthorne
PLEASANTVILLE
Reynolds Hill
Harlem Div.
UPPER EFFLUENT CHANNEL
LOWER EFFLUENT CHANNEL
SCREEN CHAMBER
LANDMARK TUNNEL
KENSICO SIPHON
KENSICO TUNNEL
AERATION BASIN
KENSICO DAM
Lake Kensico
KENSICO DIKE
BRONX DIKE
Bronx River
Line TAKING
By-Pass
Kensico
NEW RYE DIKE
OUTLET BRIDGE
RYE OUTLET
BRONX-RYE TUNNEL
BEAR GUTTER BRIDGE
BEAR GUTTER
WESTCHESTER CO
FAIRFIELD CO
Byram River
BYRAM TUNNEL
Armonk
Mianus River
CONNECTICUT
NEW YORK
LINE
El. 355
Cranberry Brook
Cranberry Pond
Little Rye Pond
Rye Pond
Line TAKING
Valhalla
WASTE WEIR
R. WASTE CHANNEL
Bronx River
CONDUIT
R. W. C.
No. White Plains
Nigger Hills
Silver Lake
Purchase
WHITE PLAINS
GREENBURG
MT KISCO
NORTH CASTLE
2000 0 2000 4000 Ft
0 1 Km

FIG. 1.

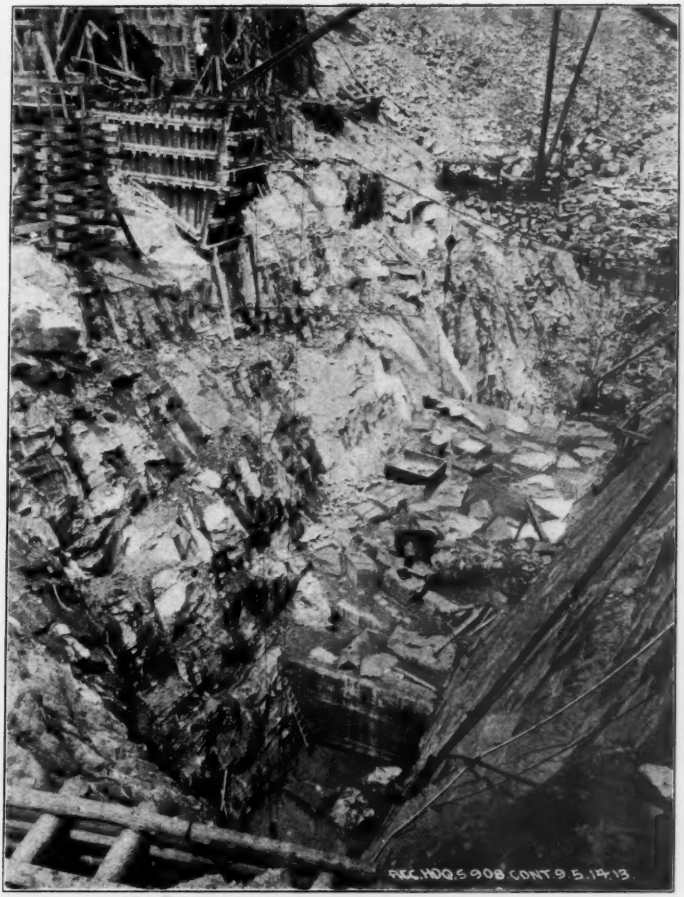
duct at this point is the same elevation as the normal surface of the full reservoir. The water after circulating through the reservoir will be drawn through a short tunnel on the west side of the reservoir about a mile north of Kensico Dam. Large gate chambers at both ends of this tunnel control the flow of water into the aqueduct. A reinforced concrete aqueduct connects the influent works with the upper effluent chamber, so that the reservoir may be by-passed and water sent directly to the city if desirable. It is expected to maintain Kensico Reservoir full, drawing upon it only in emergency.

The Kensico effluent works include an aëration basin, screen chamber, and reinforced concrete Venturi meter.

The by-pass aqueduct, connecting the influent and effluent chambers, is built along the west side of the reservoir and is a circular reinforced concrete structure 11 ft. in diameter. The reinforcing rods are $1\frac{1}{8}$ in. square twisted steel bars arranged in double rings, spaced 18 in. apart longitudinally. The construction of this reinforced aqueduct was required to be monolithic. It was built in sections about 45 ft. long, the forms for which were especially designed and furnished by the Ransome Concrete Machinery Company. The circular inside form was supported on short pier blocks located between the reinforcing rings. The entire mass of concrete forming a section was placed continuously, and special devices for compacting the concrete in the invert under the inside form and around the reinforcements were resorted to. Each section 45 ft. long was built in a day.

The upper effluent gate chamber, through which the water is drawn from Kensico Reservoir to the city, is 52 ft. square, with the gate sills at Elev. 291.3. The water is controlled by a double set of four 5 ft. by 8 ft. sluice-gates, and the by-pass aqueduct connects with this gate chamber. After leaving this chamber, the water passes through a tunnel 1 600 ft. long to the lower gate chamber. This is 82 ft. by 100 ft., with floor level at Elev. 295.32. This chamber controls the water, delivering it directly to the aqueduct or to the aëration basin, or to turbine wells, in which power may be developed by using the available head when the aërator is not in use.

The Kensico aërator is a large concrete basin 460 ft. long and



GENERAL VIEW OF GORGE.

240 ft. wide, with six lines of reinforced concrete supply pipes discharging through 1 750 nozzles arranged in rows and groups, which with different sizes and shapes of jets will make a wonderful fountain. The nozzles are designed with spiral veins, which cause the water to break into a fine spray, aiding in the oxidizing effect of the air by exposing the drops for several seconds, thus removing many of the causes of disagreeable tastes and odors. The aërator when operating will absorb about 25 ft. of available head. As the aërator will pass the entire flow of the aqueduct, it is believed to be the largest fountain in the world. The water, after falling on the floor, flows through a slot into a collecting conduit beneath the floor, which conducts it back to the aqueduct.

After leaving the Kensico Reservoir, the aqueduct is subject to a head of about 35 ft., and the cut-and-cover portion is built with heavy reinforcement. It is circular in section, similar to the by-pass, 17 ft. in diameter, and the reinforcements are $1\frac{3}{8}$ in. square twisted steel rods arranged in double rings $7\frac{1}{2}$ in. apart longitudinally.

After leaving the lower effluent chamber, the aqueduct passes through an air remover, a connecting chamber which received the water from the aërator, a screen chamber, and a Venturi meter. The latter is 216 ft. long, with a throat 8 ft. 9 in. in diameter.

The preliminary surveys for the reservoir were begun in 1906, and construction on the portion of the aqueduct adjacent to the reservoir and the effluent works was started in 1909.

By far the most important structure of the reservoir is the Kensico Dam, a straight masonry dam of gravity type, having a length on top of 1 843 ft. and a maximum height of 307 ft. from the lowest point in the foundation to the surface of the roadway on top. It is 28 ft. thick at the top, and its profile is the heaviest and most conservative of all of the recent modern dams. It is built of cyclopean masonry. The upstream side is faced with concrete blocks, and the exposed portion of the downstream side is faced with cut stone masonry. It contains about 900 000 cu. yd. of masonry, and takes rank among the notable dams of the world, not only on account of its size, but on account of the unusual

method of construction which enabled an extraordinarily rapid progress to be maintained throughout its construction. The contract for the dam and reservoir was awarded to Rodgers, Rodgers & Haggerty in December, 1909, and was assigned to H. S. Kerbaugh, Inc., in September, 1910. The amount of the contract, based on the bid prices and the preliminary estimate of quantities, is $7 953 050.

The first work to be performed under this contract was the construction of the substitute reservoir and the relocation of the highways affected thereby. The substitute reservoir was formed by two rolled embankment dikes, each about 45 ft. high, one across the outlet from the Rye Ponds and the other across the upper valley of the Bronx River. The crest of the spillways was Elev. 318. These two basins were connected by a small tunnel 600 ft. long. Together, they afforded an available storage of 5 064 000 000 gal., and lie wholly within the limits of the new reservoir. This substitute reservoir was connected with the Bronx conduit by a 36-in. riveted steel pipe two miles long. A matter of special interest in the dikes was the construction of the timber cut-off walls. These were specified to be tongue and groove sheet piling, 6 in. thick, extending from a concrete footing in the cut-off trench to a point above the flow line. The sheeting was to be placed vertically and supported by horizontal wales. The difficulty of supporting long lengths of sheeting in an upright position and placing a compacted fill close to it suggested the feasibility of placing the wales vertically and laying the sheeting horizontally as the embankment rose in height. The sheeting was composed of three thicknesses of 2-in. spruce, dressed on both sides, spiked together in such a manner that the middle piece formed the tongue. But instead of making up the sheeting beforehand, the separate boards were placed between the wales with the proper lap at joints and spiked in place.

The temporary reservoir covered 708 acres, 200 acres of which was swamp land at an average depth of about 28 ft. below the surface of the full reservoir. A large portion of these swamps were of considerable depth. Samples from a depth of 30 ft. showed more then 35 per cent. of organic matter, and they were covered by a rank growth of tussocks and other swamp vegetation.

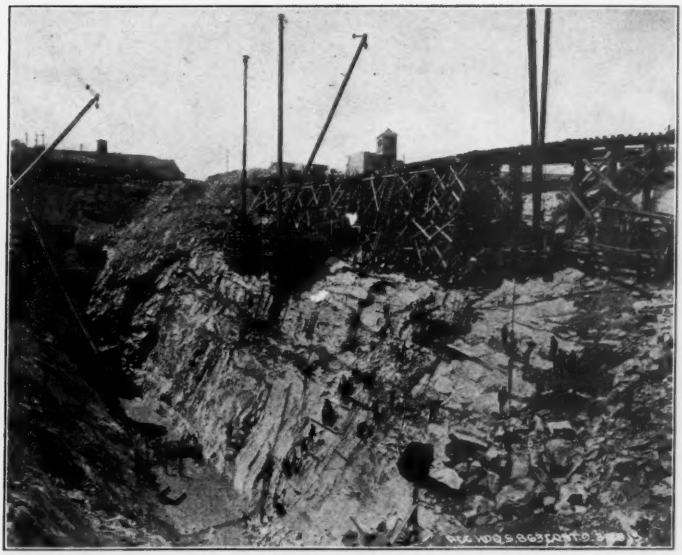


FIG. 1.
West face of gorge.

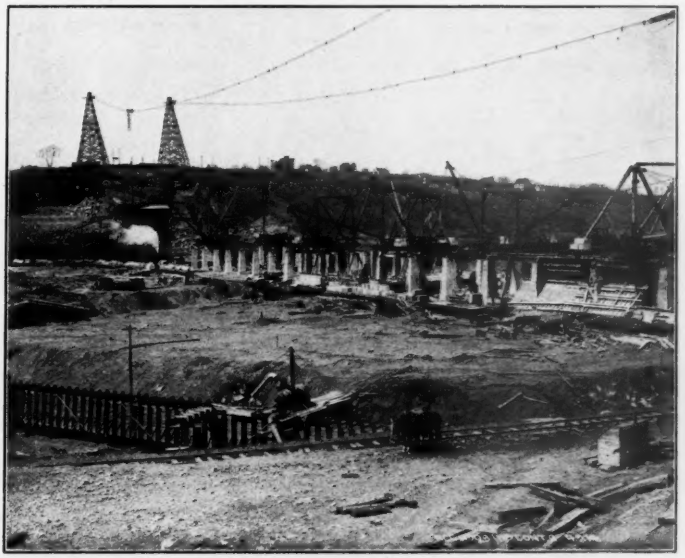


FIG. 2.
Fill on downstream face, showing method of supporting traveler tracks on concrete piers.

It was feared that these swamps would impart both tastes and odors to the water to an objectionable extent, and as it was essential to use the water as soon as it could be stored, they were cleared and covered with a layer of soil about one foot deep, which acts as a blanket to prevent the decomposed organic matter from mingling with the water. Favorable material was found in borrow pits on the sides of each swamp. Steam shovels and an equipment of narrow gage locomotives and four-cubic-yard side dumping cars were installed by the contractor. The swamps were first cleared by cutting off the surface growth, including tussocks, down to the general swamp level. After drying in piles for several months, the tussocks were easily disposed of by burning. The covering material was run out on to the swamp in ten-car trains over tracks of 60 lb. rails carried on 8-ft. ties laid on the cover. After dumping, it was spread to about 12 in. Over the shallow and dry swamps it was found that this depth of cover could easily support the tracks and train loads, but on the deep swamps, especially when they were saturated after heavy rains, the tracks would repeatedly break through the cover, and it was necessary to increase the depth to about 18 in. This would usually support the load, although it would deflect several inches as the trains passed over it, causing an alarming wave to those who were not used to it. At first the material was spread out by hand shoveling, but later the contractor provided car scrapers which were operated by locomotives.

The highway relocation involved the construction of about nine miles of new road and three reinforced concrete bridges, the largest about 900 ft. long, containing five segmental arches of 125 ft. clear span. Each arch is composed of two ribs of Melan construction, which carry spandrel arches supporting a reinforced floor. The central piers are more than 100 ft. high to the springing line. The exposed surfaces of the bridges are of granolithic finish, tool dressed.

Impounding of water in the temporary reservoir was begun August 17, 1911, and on September 8, 1911, when there was only 6 ft. of water covering the main swamps, the reservoir was put in service. A small aërator was built on the pipe line, and the quality of water from this temporary reservoir has been satis-

factory from the first, there being no objectionable tastes, color, or odor at any time.

After the substitute supply works had been completed, the old Kensico Reservoir was drawn off and the work of excavating the foundation for Kensico Dam was begun in the fall of 1911. The side hills of the Bronx Valley at the site of the dam rise about 180 ft. above the floor of the valley, the lowest point of which is at Elev. 200 above sea level. The east hill is of Fordham gneiss, and the west hill of Manhattan schist with very light cover of soil. Between these two formations is a stratum of Inwood limestone about 400 ft. thick. Geologically the valley is an eroded limb of a simple fold with a strike nearly north and south, or at right angles to the line of the dam, and an average dip to the west of 55 degrees. The floor of the valley at the dam site is about 900 ft. wide, with from 10 to 30 ft. of modified drift overlying the bedrock. Some of the material is very fine, analyses showing that 96 per cent. will pass a No. 50 sieve. The core borings of the preliminary surveys revealed a preglacial gorge in the vicinity of the contact between gneiss and the limestone about 50 ft. wide at the top and about 120 ft. deep below the floor of the valley. At the depth of 30 ft., and again near the surface of the disintegrated rock at the bottom of the gorge, layers of coarse sand and gravel were found. The bottom of the gorge still held about 40 ft. of disintegrated rock that had not been removed by the glacial scour. The excavation for the dam was started with three steam shovels, the material being removed in eight-yard car trains of standard gage, and was disposed of in the low ground below the dam. The grading for the plaza and approach took care of practically all of the excavation from the dam site, which amounted to 600 000 cu. yd. As the excavation reached the low level of the very fine material, some difficulty was experienced in supporting the shovels. The material was so fine that it held the water, and although it would stand in a vertical face 10 ft. high in front of the shovel, when it was subjected to vibration under the shovel it would soften up so that the shovels were continually settling in the soft material. Finally recourse was had to floating the shovels on rafts made in sections of three 14-in. by 14-in. timbers 24 ft. long bolted together. These sections of raft were taken up,

View of Upstream Face.

moved ahead, and placed by traveling cranes operating on the muck tracks. After the rock was uncovered, it was drilled and blasted to depths of 10 to 15 ft. and removed by the shovels.

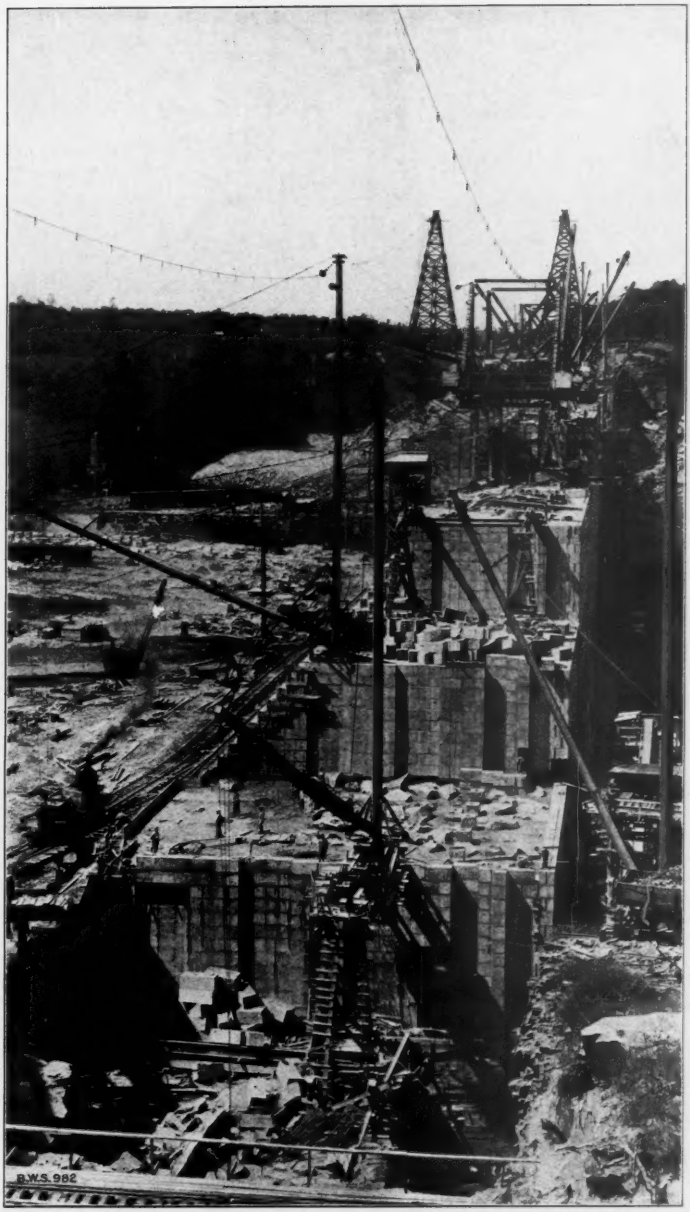
For the purpose of intercepting any possible seepage under the dam, a cut-off trench 20 ft. wide and from 20 ft. to 30 ft. deep was excavated in the solid rock foundation under the upstream face of the dam, extending the entire length, except at the ends above Elev. 300. This trench was excavated to such depths as to be below any open seams in the rock, and the sidewalls of this trench afforded an excellent opportunity for judging of the nature of the rock foundation.

The excavation in the gorge was carried along simultaneously with the rock excavation on the broad area and was prosecuted vigorously during the entire calendar year of 1912. At first the material was handled by two steam shovels into four-car trains which were hauled up an incline on the north slope of the gorge excavation. As soon as the depth was reached at which the two shovels could not work conveniently in the narrowing gorge, one was removed. The remaining shovel carried the excavation down to Elev. 80, the material being lifted in eight-yard skips by the cableways. The excavation was continued by hand until the solid contact between the gneiss and the limestone was reached. This was found at about 130 ft. below the surface of the valley.

The excavation revealed sound rock for the foundations everywhere very close to the elevations assumed from the core and diamond drill borings. These borings gave especially close results in delimiting the gorge, and demonstrated the wisdom of careful preliminary explorations. Satisfactory foundations were found at all points; even the limestone presented no unusual problems. Although similar to the formation under the new Croton Dam, it is of more sound character, and such erosions as were found were only of superficial nature. Bedding seams more or less open occurred in all three rock formations, but the cut-off trench was carried below the point where these could have any significance. Moreover, a number of drill holes crossing these seams at varying depths up to 25 ft. were made and grout pipes inserted. After a sufficient depth of masonry had been placed, careful tests with colored water under 100-lb. pressure failed to

reveal any unsatisfactory conditions. Subsequent grouting to refusal under pressures up to 100 lb. has produced a tight and satisfactory foundation. After a satisfactory rock had been reached by the ordinary methods of excavation, the foundation was prepared by removing all loose pieces by barring and wedging, and this painful operation was continued until the surface was sound and massive. The surfaces were then cleaned with jets of water and air and vigorous brooming. Just before the masonry was placed, a rich mortar was spread over the rock surface and broomed into all the seams and irregularities.

One of the fundamental features in the design of Kensico Dam is its division into sections longitudinally by transverse contraction joints. These are located about 80 ft. apart throughout the length of the dam, and greatly facilitated the construction, in that any section could be built up to any desired height irrespective of the adjoining section. The faces of the contraction joints are formed of concrete blocks laid up in such fashion as to form tongues and grooves running vertically, each 10 ft. wide. Taking advantage of this feature, the contractor conceived the plan of placing the masonry on the broad area west of the gorge by a number of stiff-leg derricks mounted in pairs on travelers, which could be moved on elevated tracks supported on concrete piers erected on the foundation for the dam. (Plate XXIX, Fig. 2.) Two lines of traveler tracks running longitudinally with the dam permitted four travelers to be placed in pairs facing each other over each section of the dam between contraction joints, thus making eight derricks available for each section. The piers supporting the traveler tracks were 6 ft. square at the base and 4 ft. at the top and 25 ft. high, and were built in place of mass concrete by the cableways. They were spaced longitudinally about 40 ft. apart, or one half the length of a section. The girders were 28-in., 80-lb. Bethlehem H-beams. The travelers were 30 ft. wide and 39 ft. long. The derrick booms were 57 ft., each operated by a double-speed 75 h.p. electric hoist. Between and on the outside of the traveler tracks were service tracks carried on piers, upon which shuttle cars operated, which brought the concrete in bottom-dumping buckets of two-yard capacity from the mixers located at the ends of the dam. The large cyclopean stone was delivered



CROSS SECTION OF DAM.

to the outside derricks over tracks laid on the refill on both the up- and down-stream sides of the dam. The advantages of this plant arrangement over those recently employed in the construction of large masonry dams are the readiness with which the derricks can be moved from section to section and the direct delivery by rail to the derricks of the materials.

The concrete blocks forming the upstream face of the dam are 2.5 ft. high and from 5 to 6.5 ft. long. They are arranged in alternate header and stretcher courses. The arrises are finished with a radius of 1 in. The blocks for the contraction joint facing are 2.5 ft. high and 5 ft. long. These blocks were all made in the special yard south of the dam, and were set in the same manner as ashlar masonry with 1 in. mortar joints.

The masonry in the cut-off trench was usually placed first, and was of a richer concrete than that in the main body of the dam, being in the proportions of one part of cement to six parts of aggregate, and no cyclopean stone was placed in the north half of the trench. The concrete in the body of the dam was in the proportion of one to nine. The blocks forming the upstream face and the faces of the contraction joints were laid a course at a time, and these served as forms to hold the cyclopean masonry, the downstream face of the dam being built against timber forms. During the busy part of the season, the concrete blocks were laid at night. The concrete piers supporting the traveler tracks were built in and became a part of the masonry. As soon as a section was completed to the level of the tracks, the travelers were moved to an adjoining section. When a considerable portion of the dam was finished to the elevation of the tracks, the piers for the next lift were built by the cableways and the tracks re-erected. Eight travelers made it possible to work on two sections at once in this portion of the dam.

The depth of the gorge made the placing of masonry in it a separate problem. A row of 90-ft. guy derricks on both sides of the gorge covered the whole area, and these were served by two concrete mixing plants located one on each side of the gorge, so that the derricks could reach the hoppers from the mixing units directly.

The placing of masonry in the gorge was begun early in March,

1913, and after the bottom was placed, it progressed rapidly throughout the season. After it reached the elevation of the derrick bases they were raised and placed on top of mass concrete piers which were included in the masonry. Early in October, construction on the second traveler lift was begun. The progress on this lift was more rapid than on the first because of the narrower section and the more uniform depth. By the end of the season, the masonry in the gorge had been completed to the same elevation as the rest of the dam, so that during the following season the traveler method was extended over the whole length between the hillsides. At the close of the season the dam was completed to Elev. 214 for a length of 869 ft. A total of 316 000 cu. yd. of masonry was placed during the season of two hundred working days of eight hours each. The best day's record was 2 250 cu. yd. of masonry placed. The cyclopean stones were all large derrick stones, many of them running as large as 8 cu. yd. During the winter of 1913–14, refill on both sides of the dam was placed to the elevation of the completed masonry, so that the entire volume of masonry placed during the year was buried.

During the early spring of 1914, the traveler tracks for the third lift were erected, the three concrete plants were relocated so as to meet the needs of the coming season, one at the base of each hill on the downstream side and the third on the upstream face at the east end. The service tracks were arranged on the refill on both sides of the dam, and the general plant tuned up for the effort of the coming season. The laying of masonry was resumed early in March. While the travelers were building section after section of the main portion of the dam, guy derricks were building the hillside sections at the east and west ends, and as these were completed up to the level of the central portion, the traveler method was extended. By the end of May, the third lift was completed and work on the fourth lift commenced. The top of the third lift, Elev. 239.5, coincided with the elevation of the terrace on the downstream face of the dam, which is the beginning of the face masonry. Above this elevation, the downstream face of the dam was formed in steps to receive the stone masonry facing to be placed later.

On the fourth lift several radical changes were made in the

CROSS SECTION OF DAM.

arrangement of the travelers. At this elevation, the width of the dam was so reduced that the whole width could be covered by a single traveler, necessitating but one traveler track. The eight travelers were now arranged in pairs, permitting the construction of four sections at a time. Instead of building mass concrete piers, sections of the contraction-joint block facing were built up and used for supporting the traveler track girders. The projecting ends of the header blocks were supported by concrete slabs or filler blocks laid with mortar joints. The ends of the girders between the joints were supported on movable timber towers. This change proved very favorable, as the timber tower and tracks could be entirely removed from the section under construction, and the block piers were more easily erected than concrete piers. The downstream service tracks for the fourth and subsequent lifts were relocated at the elevation of the terrace wall, the inner track being carried on the bench for supporting the base of the face masonry, the outer track on the piers which supported the outer girder for the third lift traveler track.

The construction of the fifth lift was similar to that of the fourth. The booms of the downstream derricks were lengthened to 67 ft. to enable them to reach the concrete tracks on the terrace. The sixth and seventh lifts were built in a similar manner. The reduced width of the dam enabled a greater depth of masonry to be laid in a day, and two courses of facing blocks were laid at a time. At the seventh lift, the piers carrying the downstream traveler rail projected above the face of the dam. The eighth and top lift, completing the dam to Elev. 370, was built with the travelers on the seventh lift track. The traveler derricks, working above themselves to the extent possible, were assisted by guy derricks placed on top of the dam. After the travelers had built all but the sections of the top lift they were occupying, they were removed and the closures made by guy derricks.

At the close of the season of 1914, the dam had been completed to the top for a length of 1 400 ft., the east end, which terminated abruptly part way up the east hill, leaving a contraction joint face 140 ft. in clear height. 489 750 cu. yd. of masonry had been placed in 221.5 working days of eight hours each, or an average of 2 211 cu. yd. a day for the entire season, nearly equaling the

best single day's work of the previous year. The largest day's work for 1914 was 3 572 cu. yd. This achievement is a record in dam construction, and is believed to be the greatest mass of masonry ever placed in a single structure in the same length of time. The accomplishment of this feat was due not only to the very liberal construction plant, but depended upon a careful arrangement of all the details and a very efficient organization. When it is considered that this work required an average delivery to the derricks of 4 000 tons of material a day, which at a maximum amounted to 7 000 tons in a day, the magnitude of the transportation problem will be better appreciated. That this supply was never seriously interrupted is the best evidence of the contractor's organization. The crushed stone for the concrete, the large fragments of cyclopean stone, and the dimension stone were all obtained from a quarry specially opened about a mile east of the dam. The cyclopean stone averaged 27 per cent. of the mass, and the cement factor for the two years was 0.84 barrels of cement per cubic yard of masonry.

The most interesting features in the plant arrangement were the use of the traveling derricks, the mixing of the concrete at conveniently located points instead of a central plant, so that the time of delivery to the derricks was reduced to a minimum, and the advantage taken of the facility afforded by the contraction joints for building up independent sections. The most interesting plant not already described was the two cableways which covered the entire length of the dam, having a span of 1 860 ft. They were carried on movable timber towers 125 ft. high. The main cable of each span was $2\frac{1}{2}$ in. in diameter. Their capacity was about twelve tons, with a running speed of about 800 ft. per minute. These cableways were used primarily for handling and arranging the plant. They were used to some extent for removing excavated material, principally from the gorge. They were not used for placing masonry except the concrete in the track piers. Two one-yard Ransome rotary mixers and three two-yard gravity mixers of the Haines-Weaver type made all the concrete used in the dam. During the second season, a large output was obtained from the latter mixers, the largest day's work for any one mixer being 653 batches in eight hours. The

mixers were located at convenient points in timbered towers of such height that the bottom hopper discharged directly into the buckets carried on the shuttle cars. Above the mixing floors were bins to which the aggregates were delivered by belt conveyors which drew the materials from storage bins. The materials were brought to the storage bins by standard railroad equipment running on overhead tracks. The freight cars which brought the cement in sacks from the mills were run directly alongside of each mixer. The sacks were unloaded by hand and placed upon belt conveyors which delivered them to the mixing floor. All of the plant at the dam, excepting the locomotives, was electrically operated by alternating current furnished by the New York Edison Company over a specially constructed high-tension power line located along the aqueduct right-of-way from Yonkers to Valhalla. Electricity is also used for operating the crushing plant at the quarries and the air compressors which furnish power for the quarry drills and the stone-dressing machines.

The concrete block plant consisted of a traveling platform spanning three rows of steel block-forms. On the platform were three one-yard rotary mixers, one over each line of forms, into which they discharged directly. The mixers were supplied by materials from overhead bins, which were in turn supplied by a telfer operating on a cantilever beam which was served by trains of flat cars carrying bottom-dumping buckets containing the aggregates. The hoist which operated the telfer supplied the motive power for moving the traveler. The blocks are all cast with the exposed face downward, which produces a very smooth, dense face. After the blocks were hard enough to move, they were piled by traveling cranes and left for thirty days to strengthen.

For the supply of all the stone required for the dam, the contractor purchased a favorable quarry site about a mile east of the dam, and built a double-track stone-ballasted standard-gage railway connecting it with the east end of the dam, his plant yards above and below the dam, and the Harlem Division of the New York Central Railroad. The production of crushed stone and cyclopean stone involved quarrying on a large scale, including blasts of 100 000 cu. yd. The material for the crushers was handled by steam shovels, and the crushing plant contained some

of the largest units ever built. The architectural plans required many large dimension stones, and an excellent stock was obtained for this purpose. The stone is a gneissoid granite, having an interesting grain and diversity of color due to the including minerals.

The work of dressing the 22 000 cu. yd. of dimension stone has progressed continuously for two years, and still involves the employment of nearly one hundred stonecutters. Much of the work is done by machinery, pneumatic surfacing tools and pneumatic plug drills being used wherever possible.

The work of the present season includes the completion of the east end of the dam and the placing of the dimension stone facing, the grading of grounds and driveways below the dam, and the final clearing of the reservoir. This work is so far advanced that it is expected to begin filling the reservoir in November, 1915.

Because of the magnitude of Kensico Dam and its conspicuous location, being at the northern terminus of the Bronx River Parkway, and the fact that it is the most imposing visible structure of the Catskill Aqueduct, it was thought proper to give it suitable architectural treatment. The design contemplates emphasizing the size and proportions of the dam. The most important feature is the cornice or finial line of the top of the dam, extending for 1 800 ft. in a strong horizontal line, including a frieze roughly carved to suggest the classic design of shield and wreath. This is flanked at the ends by semicircular cut stone pavilions of classic design. The horizontal base of the dam across the valley is marked by a broad terrace rising 10 ft. above the general level of the approach. This terrace is 1 000 ft. long and its ends are marked by twin pavilions and broad flights of steps leading down to pools and fountains. The motif of the design for the face of the dam was suggested by the structural feature of the contraction joints, and the face of each section is treated as a panel separated by heavily rusticated bands, which rise from the terrace to the coping. Within a border of smooth cut stone, the field of each panel is composed of roughly squared masonry in which appear projecting headers arranged in diaper pattern. The central portion of the face is flanked by pylons which rise from the ends of the terrace. Beyond these the panels are con-

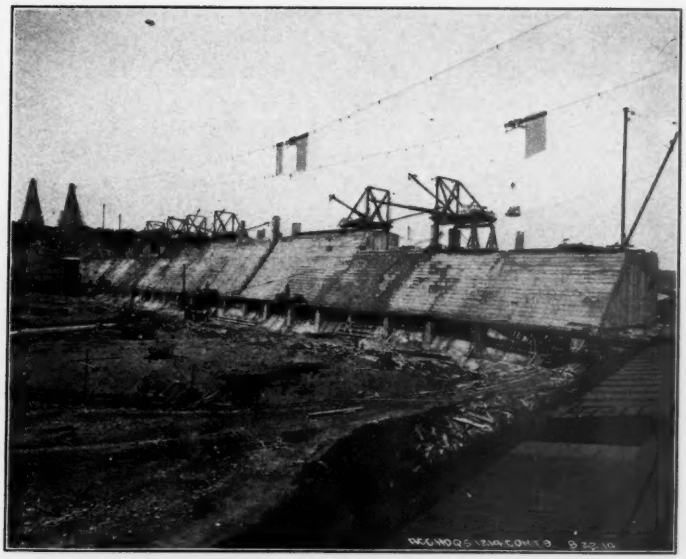


FIG. 1.
General view of dam.

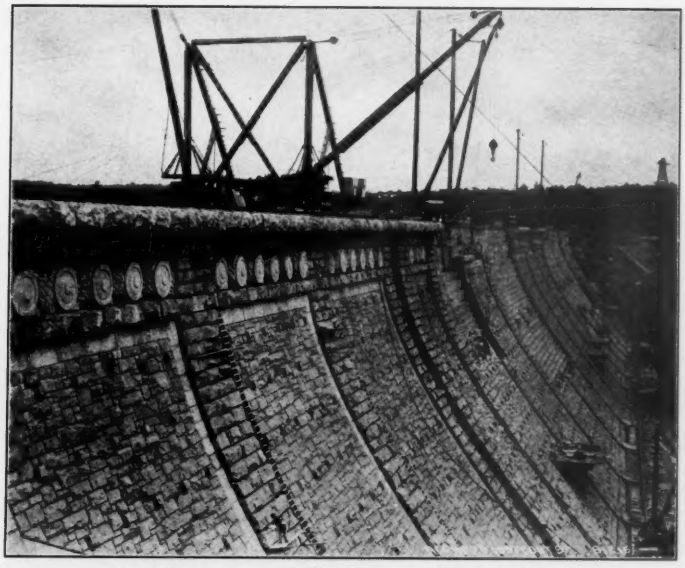


FIG. 2.
Dimension stone on face.

tinued up each hillside, making an harmonious treatment of the whole face. The torus is 4 ft. high and the frieze course 6½ ft. high. These involve very large stones weighing up to 14 tons. The rough dressing of the surfaces and the wide jointing express the magnitude of the structure, which in itself is its chief element of beauty. In front of the terrace below the dam will be a large pool with fountains, paths, and driveways. This more formal area is approached by broad avenues traversing a gradually descending plane nearly 2 000 ft. long. The whole area will receive adequate landscape treatment, and will form a suitable setting for so notable a structure.

SANITARY IMPROVEMENT OF A LARGE WATERSHED.

BY GEORGE G. HONNESS, DEPARTMENT ENGINEER OF THE BOARD OF WATER SUPPLY, NEW YORK.

[*Read September 7, 1915.*]

Tributary to the Ashokan Reservoir, now being constructed by the Board of Water Supply of the City of New York as the principal storage reservoir for Catskill Mountain water, there are 257 square miles of drainage area. A considerable portion of this is uninhabitated, being wild forest land. The population is concentrated along the valleys and consequently adjacent to the streams feeding the reservoir. This mountain region is a favorite summer resort for city people, and this fact leads to a wide variation between the summer and winter population. It has been estimated that the summer population is 10 000 and the winter population 3 000, being 39 per capita per square mile and 12 per capita per square mile, respectively. Two of the principal centers of population have public water supplies but no sewerage system; there are also many large hotels without adequate methods of sewage disposal; and the tendency of the entire region is to be exceedingly lax in the disposition of all wastes.

Fig. 1 shows the reservoir and the drainage area and the relation of one to the other, and the relative areas which are to be cared for by a trunk sewer and by individual sanitary treatment.

It has been appreciated by the Board of Water Supply that the sanitary conditions of the watershed needed improvement, and consideration of a sanitary survey made it evident that two separate methods for sanitary improvement should be considered, — one for the important centers of population and one for the outlying districts. For the former it was suggested that a sewer be built in the main valley, with branches in the side valleys to the important centers of population, the sewage to be treated at a

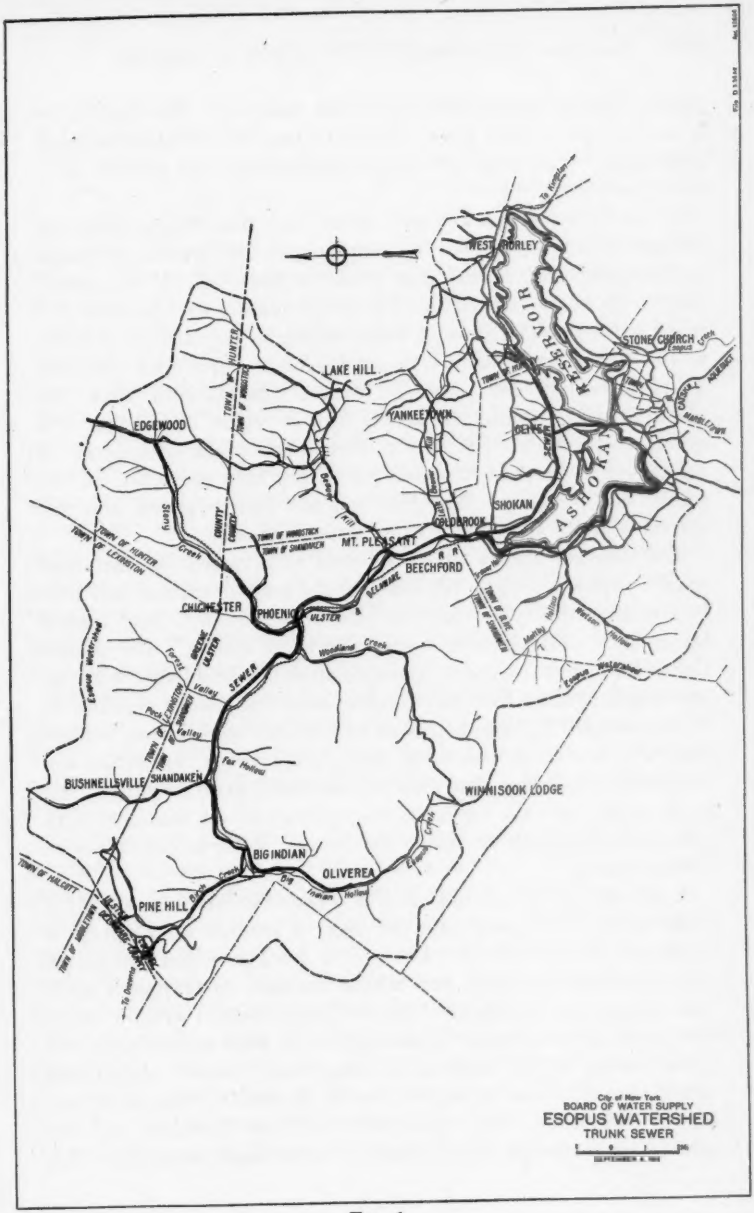

WEST HURLEY
ASHOKAN RESERVOIR
STONE CHURCH
LAKE HILL
EDGEWOOD
YANKEE TOWN
SHOKAN
COLDBROOK
MT. PLEASANT
BEECHFORD
CHICHESTER
PHOENICIA
ULSTER
BUSHNELLSVILLE/SHANDAKEN
WINNISOOK LODGE
BIG INDIAN
OLIVEREA
PINE HILL
TOWN OF HUNTER
TOWN OF LEXINGTON
TOWN OF HARDENBERGH
TOWN OF SHANDAKEN
TOWN OF OLIVE
TOWN OF MARBLETOWN
TOWN OF ROCHESTER
TOWN OF SHAWANGUNK
TOWN OF ULSTER
TOWN OF WOODSTOCK
TOWN OF ESOPUS
TOWN OF PLATTEKILL
TOWN OF SHAUNGUNK
To Newburgh
To Poughkeepsie
To Rondout
Esopus Watershed
Woodland Creek
Forest Valley Creek
Rock Lumber Valley Creek
Fat Hollow
Big Indian Creek
Big Indian Hollow
Esopus Creek
Stony Creek
Beaver Kill
Bush Kill
Marbletown Creek
Watson Hollow
Hollow
Esopus Watershed
SEWER
City of New York
BOARD OF WATER SUPPLY
ESOPUS WATERSHED
TRUNK SEWER

FIG. 1.

disposal plant downstream from the reservoir. For the latter it was concluded that resort should be had to individual sanitary treatment. This was to include improvement of privies, cesspools, barnyards, etc.

A survey for the sewer was made, and this showed that the sewage could be conducted to a disposal plant by gravity, although a short length of pressure pipe would be required. It was necessary to go to the legislature to gain permission to construct this sewer in the public highways, ample authority having been granted in the statute creating the Board of Water Supply for all other features. A bill was presented to the legislature of 1914, but failed to pass because the people of this region hoped that if a sewer was not built the city of New York would ultimately be compelled to purchase the entire territory as a protection to the purity of the water. The bill was not clearly drawn, and this helped to make the success of its opponents easy.

The sanitary survey above referred to divulged the fact that some few places had no provision in the way of privies, and that in a large majority of cases no pits were provided, fecal matter falling into a dry run or a small drainage course. The privies themselves were in many cases dilapidated buildings, with no protection against flies and no provision for proper ventilation. It was decided to furnish privies where none were in use, replace disreputable ones by new ones, repair and provide ventilation and screens for all privies that were in reasonably good condition, and in all cases place the buildings over pits about six feet deep with sides walled up with dry stone and located as far as possible from a watercourse.

A sanitary privy was designed as a portable building, so that it could be built at a shop and delivered in sections at the place of erection. The privies were 4 ft by 4 ft. 3 in., provided with ample ventilation from beneath and behind the seat up through a small box chimney to the height of the roof, a good-sized window which was screened with copper screening, and a door with a latch and spiral spring which insured it being kept closed. Additional ventilation is secured by holes bored in the peak covered by screening on the inside. The construction of these buildings cost the city about seventeen dollars each for labor and materials. This

does not include the cost of erection, which is small when the cost of hauling is excluded.

The statute creating the Board of Water Supply gave it authority to enter upon private property to improve sanitary conditions, the entire expense to be borne by the city of New York. With this authority, a start was made in improving the outlying districts. This work was at first viewed with distrust by the natives, and much objection and many prejudices had to be overcome before the work went smoothly forward; but under the skillful handling of Mr. Sidney K. Clapp, a member of this society, all these difficulties were gradually overcome. At places where our efforts were met by strong objections on the part of the property owners, the work was temporarily deferred and adjacent places improved, but ultimately the owner who had first objected asked that improvements be made on his property. By this procedure, we did not force our rights under the law, but by tact and diplomacy accomplished the same object without friction, retaining the goodwill of the people among whom we were working. It is only fair to say in passing that the bulk of the derelictions from good sanitary conditions were due to thoughtlessness and not to a wilful desire to injure their neighbors.

The work of improving the outlying districts was nearing completion when the 1914 legislature refused to pass the Esopus Valley Sewer Bill, so that it was decided to follow the above-outlined policy of individual treatment throughout the entire watershed.

Incidental to this work, an inspection has been made of all premises supplied with running water, and the means of disposal of sewage investigated. The results of this inspection are recorded in sketch form, with sufficient notes to record the actual conditions at the time of inspection. Where conditions need remedying, work is being undertaken to build or replace cesspools or install adequate methods of treatment.

For the work a gang of from ten to twelve men has been employed during the entire year, although little can be accomplished on outside construction in the winter season. Since the work started, a total of about 600 premises have been improved, 112 of this number having been provided with new privies, 7 with new

cesspools, and about 20 with cesspools improved and made more efficient. An incinerator has been built to dispose of the garbage of one community, with the understanding that it will be operated by the village authorities.

These efforts have brought about a noticeable improvement in conditions, and have awakened the people of the region to an appreciation of the necessity for better sanitary conditions.

In all this work we have profited by the assistance of the local health officers of the towns, who have shown their willingness to coöperate in bettering the health conditions. We have also been aided by the State Health Department, which has shown a marked appreciation of the necessity of guarding the public health through its potable water supplies.

ELECTRICALLY OPERATED VALVE INSTALLATIONS AND THEIR CONTROL FROM A DISTANCE.

BY ALFRED WILLIAMSON, MECHANICAL ENGINEER, DEPARTMENT OF WATER SUPPLY, GAS, AND ELECTRICITY, NEW YORK.

[*Read September 8, 1915.*]

In the event of a break in any part of the high-pressure system in Manhattan, it is possible to immediately divide the network of mains into three districts from one of the pumping stations by means of electrically operated gate valves in the streets.

Two of these districts are separated by a line which extends across the city about midway between the two stations, and the third is wholly included within the limits of one of these larger districts and constitutes what is known as the duplex system. This protects an area on the southeasterly side of the city, the mains in that section being so connected that in the alternate streets they receive pressure from one feeder and in the other streets from another feeder, both of which are separable at the pumping station, the only physical connection between the two sets of mains in the streets being through the motor-operated valves controlled at the stations. The various hand-operated valves on the boundary lines of the districts are always closed. In order to maintain good distribution, the motor-operated valves are ordinarily kept open.

Two of these valves were installed in 1911, one at New Chambers Street near Pearl about one-half mile from the Oliver Street Station, and one on Houston Street near the Bowery, about one and seven-eighths miles from the Oliver Street Station. These are 16-in. Chapman valves operated with 2.5 h.p. 230-volt motors. The power is taken from the nearest service box in the street, and the operating or control cables are carried to Oliver Street Pumping Station in ducts. The operating or auxiliary current is 115 volts.

In 1913 three more valves were installed, one in connection

with the duplex system described above and two for the purpose of separating the stations. It was decided at the time to keep the stations regularly separated, and for that reason, on the theory that the valves would be opened with full pressure on one side, 5 h.p. motors were used in these two instances. It has proven impractical, however, to keep the stations always separated, principally because of the difficulty of giving reliable service on the border line, as alarms are frequently sent from boxes some distance from a fire, and the pressure might be applied to the wrong side of the system.

The distances from the point of control for these recent installations are as follows: The valve located on the Bowery south of Houston Street is one and one-half miles from the Oliver Street Station, the one located at Stone Street near Whitehall Street is one mile from the Oliver Street Station, and the one located at North Moore and Hudson streets is one and three-quarters miles from the Gansevoort Street Station.

In each station there is a panel board with labeled operating switches for each valve and index lamps showing red when the valve is open and green when the valve is closed. When the switch is thrown the motor in the vault is started by means of an automatic starter operated by a auxiliary circuit. The motor is geared directly to the operating nut on the valve stem. Attached to and revolving with the operating nut is an extension sleeve provided on the outside with a fine thread on which the reversing switch collar travels as the sleeve revolves. The position of this collar is adjustable so that the limits of its travel may be accurately set. The operation of the reversing switch results in shutting off the motor and reversing the field connections for the next start. The signal lamps at the station and in the valve vault are also changed in this operation.

The only mechanical difficulty encountered so far has been the separation of the extension sleeve from the operating nut on one valve. This permitted the motor to drive the wedge down on the seats rather hard before the overload relay broke the circuit. The operating nut and sleeves are now made in one piece, and no more difficulty is anticipated from this cause. The electrical repairs in the past two years to the five valves have cost $120,

which was expended principally in replacing solenoids and coils in the panel boards in the vaults, which while sealed with gaskets and heated by a 16 c.p. carbon lamp are still to some degree affected by dampness. A repair charge averaging one dollar per month per valve, however, is not alarming.

The valves are operated every day from the station, and are inspected, cleaned, and lubricated every month. The cable insulation is tested every month. It may be interesting to note that the February test on one cable indicated an insulation resistance of 1 655 megohms per mile, while the same cable in July possessed an insulation resistance of only 365 megohms per mile. It is expected that next February the resistance will be back to 1 655.

The two valves originally installed cost $9 895, including vaults, panel boards, and control apparatus. The cables cost $3 200. The three later valves were installed with the rest of the distribution system and their cost is not definitely known. The cables, panel boards, and all control apparatus for these three valves cost $10 397. In order to determine upon proper charges to be paid for power for operating these valves, tests were made in opening and closing with 200 lb. pressure on one side. The maximum power at the moment of starting to close was 5 h.p. The maximum time for closing was 25 seconds; the maximum power at the moment of opening was 4.3 h.p., the maximum time of opening being 28½ seconds.

It was expected that some difficulty would be encountered in keeping these vaults dry, and where permissible drains have been installed through traps to the sewer. Several of the vaults, however, are too low to be so drained, and the installation of siphons was considered, but they have not been found to be necessary. Leakages from valve stuffing boxes are almost wholly avoided by the monthly inspection. The operators at the pumping stations are instructed to close all motor-operated valves when a sudden or unusual discharge occurs while the station is operating at a fire or while the system is not under pressure. When pumps are in operation, the station operator is at the switchboard and will detect a sudden discharge immediately on the Venturi meters directly in front of him. When the station is not pumping, however, the operators are not attentive to the meters and, therefore,

signal bells and automatic cut-outs have been installed on the low-pressure by-pass meters connecting the supply to the high- pressure system. The ringing of the bell will, of course, call the operator's attention to the unusual flow through the meter, and the automatic cut-out will prevent the loss of mercury which would otherwise result from such flow.

DISCUSSION.

MR. WILLIAM F. SULLIVAN. I would like to ask how long after starting pumps the pressure is up on the whole system.

MR. WILLIAMSON. The pressure is up within half a minute after the pumps are started; within a minute, usually, after the alarm is received.

PUMP SLIP TESTS AS AN AID TO EFFICIENCY IN THE OPERATION OF PUMPING ENGINES.

BY H. T. HAVILL, ASSISTANT ENGINEER, DEPARTMENT OF WATER SUPPLY, GAS, AND ELECTRICITY, NEW YORK.

[*Read September 8, 1915.*]

There is an abundance of data on the method of obtaining efficiencies in the steam end of pumps, and much time and labor is spent in accomplishing that end, while in most cases very little concern is given to determine the condition of the water end, where in many cases the greatest economy can be secured, unless there are definite outward indications of something wrong.

The water end of a large pumping unit is the vital end, from the water-works engineering viewpoint, for while the steam end may be working with the highest degree of fuel economy, slippage in the water end would entirely nullify the efficiency of the unit. Pumps in our stations contain as high as 480 small valves in the water end, any one of which is liable to accidental damage or wear resulting in sudden and unobserved development of slippage.

It is necessary to know frequently the quantity of water the pump will displace per revolution, to make up an honest daily log sheet from which the efficiency of the unit and the actual amount of water delivered for consumption may be calculated.

In the New York City water works, regular quarterly pump slip tests are made with a pitometer to accomplish two very important ends, the first being to determine the condition of the water end of the pump and the second to determine for record the amount the actual discharge differs from the theoretical so as to know the net gallons per revolution delivered.

It is seldom when these slip tests are made that we do not find a number of the pumps slipping from 10 to 15 per cent., and very observing operating engineers when told the amount can hardly believe it, due to the absence of any blowing, pounding, or other outward indications of inward disturbances. However, when he

opens up the water end of the pump he invariably locates the trouble and the slip is cut down often as low as 2 to 4 per cent.

To illustrate by an actual instance the value of the determination by slip test of the condition of the water end, I give below the results obtained in a recent case before and after the slip determinations and repairs.

Cost of pumping.....5c. per million gallon feet.
Theoretical displacement .....10 mil. gal. per day.
Discharge pressure.....50 lb. or 115 ft.
Total daily work performed.....1 150 m. g. f.
Slip of pump first test.....13 per cent.
Loss per day of energy due to slippage.....1 150×.13=149.50 m. g. f.
Loss per day in fuel consumption and other operating expenses,
149.50×.05=$7.47
Slip of pump after repairs.....3 per cent.
Net saving in slippage due to repairs.....10 per cent.
Saving per day in energy.....1 150×.10=115 m. g. f.
Saving per day in fuel consumption and other operating expense,
115×.05=$5.75

In the above case, after the slip test revealed a faulty condition, the water end of the pump was opened up and examined. It was found that there were six springs broken, and a piece was out of one valve, which had been renewed only a few days previous. This condition was not apparent from the working of the pump and, had it not been for the slip test, would not have been known.

To obtain the most value from the slip test when trouble in the water end is indicated, the pump should be tested again as soon as repairs are made, to determine the amount of saving and to know that the trouble has actually been corrected. It often happens that the engineer when overhauling the pump will locate some small trouble with the valves or springs and repair them and, believing that that was the whole difficulty, close the pump up again and not search further, when the greatest trouble may have been overlooked.

The necessity of the determination by the slip test of the actual gallons displaced per revolution is of decided importance as affecting the accuracy of the records of output, and needs no discussion.

LAYING WATER PIPES IN CONGESTED STREETS, NEW YORK CITY.

BY M. BLATT, C.E., ASSISTANT ENGINEER, DEPARTMENT OF WATER SUPPLY, GAS, AND ELECTRICITY, NEW YORK CITY.

[*Read September 7, 1915.*]

New York City, in consequence of its character as a still growing metropolis, has in almost every field a range of conditions from the simplest to the most complex. Thus there are many sections of the city in which pipe laying is no more difficult than in any small town or village, but in lower Manhattan any operation which involves the disturbing of the street surface and calls for underground construction brings with it, in addition to the usual engineering problems, a multitude of incidental ones, which must also be handled and solved by the engineer as a part of the whole engineering work under his charge.

In the narrow, curving streets of lower Manhattan, crowded normally to the limit with pedestrian and vehicular traffic, any constriction of the roadway by excavations in the street creates a traffic problem of first-rate importance. Allied therewith is the problem of arranging and carrying on the work so as to reduce to a minimum interference with normal business along the street. No less important is the safeguarding of the public against accident. Even minor accidents in an area of large crowds and high values have potentialities for heavy damage suits against both the contractor and the city. However, all of these matters are but incidental to the work. The principal problem lies not above but below the street surface. Crowded as the roadway may seem, the space below it, in lower Manhattan, is still more congested.

Many of the roadways downtown are less than twenty-five feet in width, some being as narrow as ten feet. In the space on each side of the sewer, which often occupies the major portion of the street, there are crowded, in irregular alignment, water mains, a multiplicity of gas mains, duct-banks and distributor conduits

for telephone, telegraph, and electric power service, pneumatic tubes of the mail service and of the various telegraph companies, steam pipes encased in jackets increasing their diameter more than double, and a number of other minor pipes and conduits. To these there must be added, in some important cases, the substructure and power conduits of the underground electric trolley, the Rapid Transit Subway, with its shallow covering, the column bases of the elevated railroad, and the tracks of the steam railroads and of the storage battery and horse-drawn street cars. The roadways, narrow as they are, are often further encroached upon by sidewalk vaults extending well beyond the curb line, and in some isolated cases beyond the middle of the street.

In the broader avenues, also, the available space is occupied by trunk mains and heavy lines of conduits. Fifth Avenue, with a forty-foot roadway between sidewalk vaults, contains two 48-in., two 36-in., a 20-in., and a 12-in. water pipe, seven gas mains, and four heavy banks of ducts. Broadway, near Twenty-fifth Street, with a 45-ft. roadway, has in addition to the trolley tracks and conduits, ten gas mains, a 12-in. water pipe, and five banks of ducts, the largest of which is 4 ft. wide and 2 ft. deep. In Tenth Avenue, the roadway of which is 60 ft. wide, there are two tracks of the New York Central Railroad, a street-car track, a 30-in., 20-in., 16-in., 12-in., and 8-in. gas main, two small and one large bank of ducts, and a 36-in., 12-in., and 6-in. water main. Similar conditions obtain in others of the wider streets.

The subsurface structures usually found in the street occupy the space between planes two feet and seven feet below the street surface, forming a network which often makes it impossible to excavate below a depth of two feet, without removing one of them. At street intersections, which in this section are closely spaced and often irregular, this network becomes a complete tangle. A large portion of lower Manhattan is low-lying, and the sewers are old and at shallow depth. Tidewater and sewers themselves add to the difficulty of finding room for an additional pipe.

In this crowded section of lower Mahnattan, considered by many the most congested with subsurface structures in the world, there were laid within the last nine years one hundred and twenty-eight miles of new mains comprising the Manhattan high-pressure

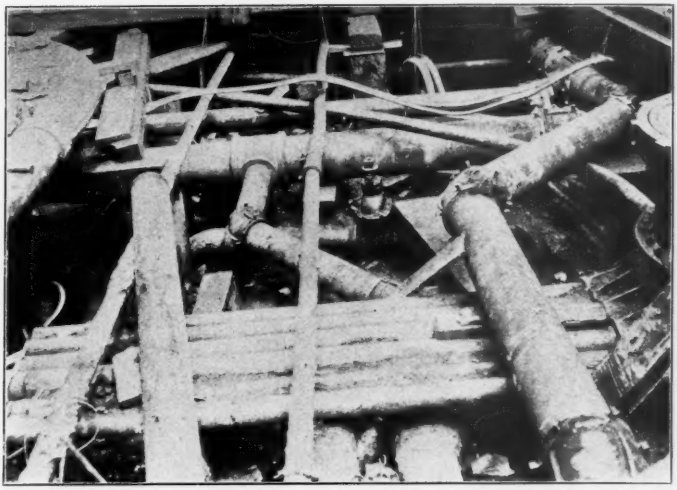


FIG. 1.

Southwest, Broadway and Spring Street, looking north. May 5, 1914.

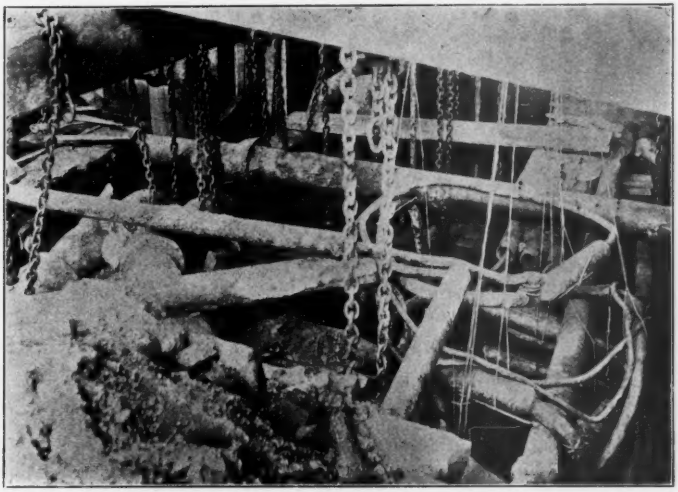


FIG. 2.

Northwest, 9th Avenue and 23d Street. Showing obstructions to be moved to permit the enlargement of the Electric Company manhole. Looking east in excavation, showing Electric Company subway running east and west on north side of 23d Street to the right. April 8, 1910.

fire system; a complete new network of water pipes, the laying of which involved the tearing up of almost every street within the entire district south of Thirty-fourth Street on the west side, and south of Houston Street on the east side of Manhattan Island.

Investigations of subsurface conditions in advance of construction work were at no time complete enough to determine even a general alignment for the new pipe in the street. When the first section of the Manhattan high-pressure system was planned the Bureau of Subsurface Structures, a recording bureau, had not been established in Manhattan. The attempt was made to determine in advance the location for the proposed mains by extensive test pit digging and plotting of the structures found therein. This attempt was abandoned as too costly, and the information obtained was found to be of little value. The alignment of the new mains was almost uniformly determined from an examination of test pits dug as the work progressed, together with such information as could be obtained from the incomplete records of the various departments and public service corporations, and from surface indications of existing subsurface structures. Some special investigations were, however, made in advance of the work, covering points known to be exceptionally difficult and complicated, such as street intersections along the route of the Rapid Transit Subway. The selection of locations for hydrants required a complete investigation and plotting of sidewalk vaults, which in the business section of Manhattan exist in front of almost every building. Detailed surveys of many of these vaults were required for the purpose of planning the construction of recesses to be built therein for the setting of hydrants.

A most important item of the work was thus the alteration and reconstruction of existing structures, which was necessary to make room for the new mains. These alterations were both extensive and costly. In connection with a contract for 14 miles of mains out of the total of 128 miles mentioned, existing water mains were rearranged at 234 locations, sewers and sewer structures were altered or reconstructed at 104 points, 55 waterproof recesses were built in existing sidewalk vaults to provide room for hydrants, and there were issued to public service corporations 649 orders for alteration, removal, or reconstruction of pipes, con-

duits, or other structures owned by them. The cost of the last-named item to the companies was a considerable one. In William Street, south of Maiden Lane, the reconstruction of a heavy bank of ducts for telephone cables cost the company owning it $5 000. Alterations to gas mains ordered during the year of 1914 in connection with the laying of these new water mains amounted to approximately $20 000.

The service of the public service corporations in many sections would not bear lengthy interruption without great inconvenience and often monetary loss to their consumers. Compelling quick action by the companies and assuring coöperation with the city and its contractors was often difficult. Yet there were many instances, such as the intersection of Frankfort and William streets, where, in accordance with special arrangements, five public service corporations removed their structures, which were badly intertwined, and replaced them again on the same day, a holiday, after the city's contractor laid the new water mains across the intersection. Many delays were, however, unavoidable, and in these cases the complaining citizen with letter-writing tendencies was in evidence.

At many points unusual construction had to be resorted to, or special provisions made to carry on the work. At Fourth Street and Broadway, after a number of unsuccessful attempts to lay a 20-in. main at normal depth, a small timbered tunnel was driven under Broadway at a depth of seventeen feet, and the main laid therein. In West Broadway, the trunk sewer is so close to the surface of the street that practically at all of the street intersections the mains had to be laid below tidewater, crossing the street underneath the sewer, which itself is built on treacherous ground. Similar conditions existed along Sixth Avenue and along the streets near the river front. The mains in Broadway and Sixth Avenue, and along a portion of West Broadway, have been, or are now being, rearranged in connection with subway construction. The old Rapid Transit Subway is at many points so close to the street surface that it was necessary to reconstruct sections of the subway roof to provide room for laying a main across it. Along Seventh Avenue the shallow depth of the subway north of Twenty-third Street made it necessary to lay the new

FIG. 1.

6th Avenue and 23d Street. Showing pipes during trolley construction, 1897.

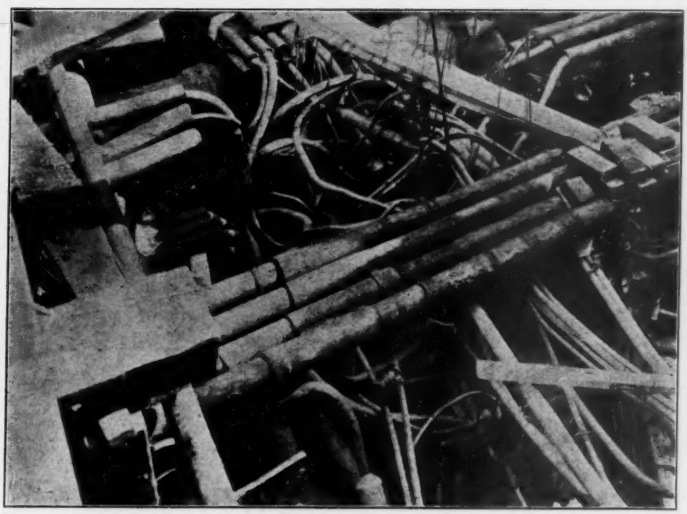


FIG. 2.

Southwest, Broadway and Houston Street. Looking southeast, showing cables in Electric Company manhole and pipes surrounding same, during Rapid Transit Subway construction. Manhole in course of reconstruction. March 20, 1914.

FIG. 1.

22d Street, east side of 4th Avenue, looking west.

FIG. 2.

Northeast, 6th Avenue and 12th Street. Rearrangement of pipes made necessary by construction of McAdoo Tunnel. Consolidated Telephone and Edison Service Company's service box spanning two 20-in. water mains with four 4-in. I-beams. Clear span, 5 ft.

main under the sidewalk, destroying thereby a number of sidewalk vaults along the street. In lower Fifth Avenue and lower Broadway, and at many other points, traffic conditions made it impossible to do work in normal working hours, and practically all of the work in these streets had to be done between Saturday noon and Monday morning. At many street intersections existing pipes formed such a complicated network that the entire intersection had to be tunneled, in some cases for a distance of one hundred feet, and pipe dragged in. Where this occurred, the network of piping formed an excellent roof for the tunnel. On Center Street, south of Canal Street, a 20-in. high-pressure main was laid in a gallery constructed in connection with the Center Street subway. This gallery runs underneath the buildings on the west side of the street. Further south, the pipe is laid under the stairway and portals of the Tombs prison.

In digging the trenches, many interesting objects were uncovered. Old wooden water pipe of the early part of last century was very common. Much of it was in a good state of preservation. The wrought-iron bands at the bell ends were of especial interest. Wrought-iron wedge gates in these pipes were more rare. A bronze driven tap with a piece of lead pipe attached was found in one of these wooden pipes. Cannon balls and coins of the Revolutionary and Colonial periods were excavated in the streets near the south end of the island. At a number of points skulls and other human bones were plentiful. A broken coffin in Washington Square contained, among other things, a fine, red wig, and close thereto a pair of old brass knuckles were found. On Elizabeth Street, under the sidewalk, at a point where hundreds of people pass each day, there existed an empty brick well 28 ft. deep, covered over only by a badly broken piece of bluestone flagging. In Beekman Street, a five-way casting with four 6-in. and one 10-in. branches formed a part of the old water main in the street. A number of structures, privately owned, occupying the street without franchise, were uncovered. Among them was a small tunnel across the entire width of the street, built to transmit power from one building to another opposite. In a number of downtown streets abandoned wrought-iron mains of an old steam distribution system were removed to make room for the new mains.

These steam mains were, for insulation purposes, enclosed in a box filled with lampblack which attached itself to all of the workmen and to many of the passersby. On Front Street, for a distance of about two blocks, the trench pictured the history of the water main system for the last century. In this trench there were exposed the old wooden water pipe, an abandoned 6-in. water pipe laid early in the century, a 6-in. water pipe laid in 1888, and a 12-in. water pipe laid in 1904. The removal of the first three made room for the new high-pressure main.

That adverse conditions and the many difficulties encountered had little effect upon the quality of the resulting work, which was safeguarded by exacting specification provisions, is best shown by the results of the hydrostatic tests to which these one hundred and twenty-eight miles of mains were subjected after installation. The maximum rate of leakage allowed was four gallons per linear foot of pipe joint per twenty-four hours under a pressure of four hundred and fifty pounds maintained for twenty minutes. In the most difficult district covered, the average recorded leakage on fourteen miles of mains was only 1.7 gal. per foot of pipe joint per twenty-four hours. It is well, therefore, in even the most difficult situations, to remember the motto of one of the contractors' superintendents, — that nothing is difficult or impossible if you have the men and the money.

DISCUSSION.

Mr. J. M. Diven. Mr. Blatt's paper is going to be a great comfort to the speaker in years to come; when he thinks he is having trouble with a complication of pipes, electric ducts, etc., he will reach for the volume in which this paper is printed, and be convinced that he has very little trouble.

President Metcalf. It reminds me, Mr. Diven, of the comments of a witness on the witness stand in the Denver case, who under cross-examination on the possibility of using a trenching machine in the heart of the city replied that he saw no difficulty in doing it. I could not help wondering, when I saw these views, whether the gentleman would have said that a trenching machine could have been used here.

FIG. 1.

19th Street, west side of 4th Avenue, looking south.

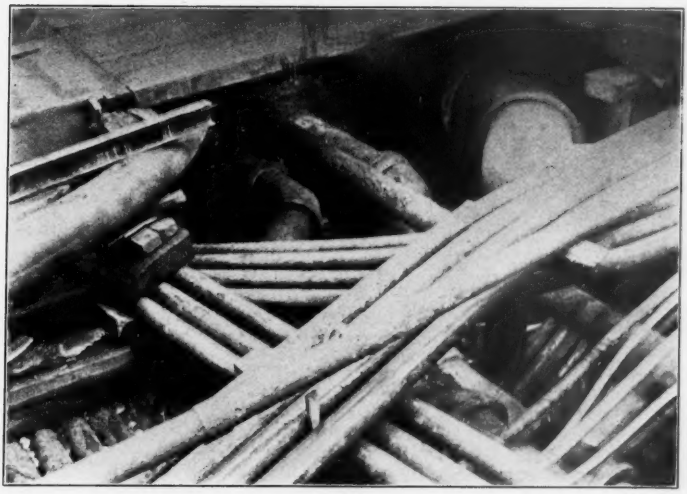


FIG. 2.

Southeast, Broadway and Pearl Street, during Rapid Transit Subway construction. Looking southwest showing three banks of Electric Company subway ducts entering manhole, and also general conditions. December 14, 1914.

MR. DIVEN. The speaker tried a trenching machine in a city street not quite as thickly populated with water pipes and underground structures as the streets shown by Mr. Blatt, and half a block brought trouble enough to stop the work. The gas company, sewer department, and all of the householders were up in arms, and with good cause, for the machine left wrecked gas services, sewer laterals, etc., in its wake.

MR. BLATT. Specifications drawn in 1904 for some of these new mains contained a provision permitting the use of trenching machines. Their use was, of course, out of the question. On the contrary, short-handled picks and shovels were needed and used constantly, and one or two under-sized workmen were required in each gang. It was not unusual for a man to work for days in a cramped place shoveling earth into a pail with a little coal shovel, the pail being hoisted to the surface when filled.

CONTROL OF PUBLIC WATER SUPPLIES BY THE CONSERVATION COMMISSION OF THE STATE OF NEW YORK.

BY RUSSELL SUTER, ASSISTANT CIVIL ENGINEER, CONSERVATION COMMISSION, ALBANY, N. Y.

[*Read September 9, 1915.*]

In thinly settled parts of this country, especially where rainfall is abundant and streams numerous, there is little pressing need of state control of water-supply matters, and it has been the custom to allow each community to take possession of and use such water supplies as it saw fit. This has not always worked out well in practice, particularly in regard to the quality of the water supplied. As the density of population has increased and as cities have become large and their needs for water great, it has been found that the interests of the whole population require that the state shall intervene both to protect the public health and to act as umpire in apportioning among the various communities the water-supply resources needed by each. Practice in this regard has differed markedly among the various states which have taken up this work. This paper attempts to give a general outline of the work already done along these lines in the state of New York, together with some discussion of future possibilities in such matters.

Prior to the year 1905, the state of New York exercised control and supervision over public water-supply systems only through the legislature and the State Department of Health. The health authorities have only advisory powers. The commissioner of health has power to investigate any public water-supply system, to determine by inspection and analysis the quality of the water supplied by it, and to report his findings with recommendations. He has, however, no authority to compel compliance with his recommendations, and a municipality can continue to supply to its inhabitants water which he has condemned on sanitary grounds.

Legislative authority has been exercised to authorize certain cities to take water from stated sources, but more often in the direction of restraint than otherwise. Thus numerous special acts have been passed to prevent cities from entering neighboring counties in order to obtain a supply of water and other similar restrictions, most of which were directly aimed at the city of New York. This special legislation at times recoiled upon those it was intended to protect, as, for instance, in Dutchess County, where the restrictions are so drastic that villages in that county have difficulty in obtaining water supplies for themselves.

In 1905 New York City made application to the legislature for the powers necessary to enable it to obtain an additional supply of water elsewhere than from Croton watershed. In considering the needs of the city, the legislature seems to have decided that it was advisable to establish a state body which should have control of the distribution of the water-supply resources of the state among the inhabitants thereof, and in the session of 1905 not only passed an act creating the Board of Water Supply of the city of New York and authorizing that city to go beyond Croton River for its water, but it also created the State Water Supply Commission with broad powers over all municipal water-supply systems.

By this act of 1905, the State Water Supply Commission, composed of five members appointed by the governor, was created, and it was specified that thereafter any municipality or civil division of the state which proposed to acquire lands for a new or additional source of water supply must first submit the project to that commission and obtain its approval thereof. This act applied only to municipally owned water-supply systems, and only to projects which involved the acquisition or taking of land. Subsequently this law was amended. In 1906 it was made to apply to privately owned water-supply systems. Other amendments of minor importance followed. Finally, in 1911, the State Water Supply Commission was merged with the Forest, Fish and Game Commission to form the Conservation Commission, and the powers and duties of that commission in regard to water supplies were somewhat extended.

As the law now stands, no municipality, person, or water supply

company, proposing to install a new water-supply system or to obtain a new or additional source of water supply for an existing system, can carry out such a project until it has been submitted to and approved by the Conservation Commission. Formal petition in writing must be made to the commission, accompanied by plans, specifications, analyses, and reports bearing upon the matter. Upon receipt of such application, the commission causes notice to be given that on a day named it will hold a public hearing upon this application. At this hearing the applicants are required to give oral testimony with regard to the project, and any person who has previously filed objections to the granting of the application may be heard in opposition thereto.

After closing the hearing, the commission must within ninety days make a decision on the application. Originally, before approving such a project, the commission had to make in the affirmative the following determinations:

That the plans proposed are justified by public necessity.

That such plans are just and equitable to the other municipalities and civil divisions of the state affected thereby, and to the inhabitants thereof, particular consideration being given to their present and future necessities for sources of water supply.

That said plans make fair and equitable provisions for the determination and payment of any and all damages to persons or property, both direct and indirect, which will result from the execution of said plans.

The Conservation Law modified this last determination by inserting the word *legal* before the word *damages*, and this law also required two additional determinations:

That the plans provide for proper and safe construction of all work connected therewith.

That the plans provide for the proper sanitary control of the watershed and the proper protection of the supply, or provide for proper filtration of the supply.

In deciding an application, the commission must make its determinations and decision in writing. It can either approve the application as submitted, or with such modifications as it may determine to be necessary in order that it may make the above determinations, or it may reject the application entirely. The

commission may allow an application to be withdrawn, amended and re-submitted.

Prior to the enactment of this law, any community or any water company which had a contract for the supply of water for public purposes to any community could exercise the right of eminent domain to take any source of water supply not already appropriated for a public use. Since 1905 this right has been restricted by the requirement that a state commission must first approve of such taking. Undoubtedly the chief purpose of this was to prevent the appropriation of water rights by a powerful community to an extent such as to hurt the water-supply interests, present or future, of smaller communities — especially of such as had not yet established a water-supply system. It was also intended to prevent the speculative taking up of water rights for possible use in the remote future. It was clearly intended that no sources of water supply should thereafter be acquired except after careful consideration of the needs for water of all communities that might be supplied from each source. That such was the case is more clearly shown by certain further provisions of the law which will be mentioned later.

This matter of the apportionment of the water-supply resources of the state among the inhabitants thereof was undoubtedly the first consideration leading to the enactment of this legislation. As a matter of fact, it does not enter to any great extent into the considerations given to the majority of applications. It will, however, be of increasing importance in the future, as the number of systems and the demands for water must continue to increase.

In granting authority to the city of New York to go beyond Croton River for water, the legislature provided that, after an additional supply of water was obtained by that city, it should be lawful for any municipality in Westchester County to purchase a certain limited amount of water from any portion of the water-supply system of the city, and also that, if water from Esopus Creek should be taken by the city, the city of Kingston should have similar privileges. Thereafter the city of New York made application to the State Water Supply Commission for permission to take water from the Catskill Mountain sources. The commission withheld its approval of this project until additional legislation

was enacted, which provided that any municipality in the watersheds of Esopus, Rondout, or Catskill creeks, in the counties of Ulster and Greene, might take water from any of the new reservoirs to be built in those counties. Again, in approving the application of the city of New York for additional supplies in Nassau County, the Water Supply Commission required that municipalities in that county be permitted to take water from the New York City system under certain restrictions as to quantity taken and rate of payment therefor. In later applications the Conservation Commission has granted applications to municipalities to take water from sources already used by other municipalities, but in order to safeguard the rights of the prior user of these sources it has limited the amount of water which may be taken by the applicant. In other cases, permission has been granted to take water from some source, but the right has been reserved to allow other municipalities to take water from the same source.

The third of the original determinations has caused more discussion than any of the others. At the time of the enactment of this law, it was evident that New York City was about to take extensive tracts of land and build large storage reservoirs. It was felt that provision should be made for the payment of damages to persons and property upon a scale hitherto unknown in this state. The original Board of Water Supply act provided in detail for the procedure in the case of condemnation of property and also provided that the owners of property which was not taken by the city, but which was damaged by the city's operations, should be compensated. Before approving the city's application for the Catskill Mountain sources, the State Water Supply Commission required a still more liberal measure of damage and would not grant the application until legislation was enacted which provided that the city: Construct and forever maintain the necessary highways and bridges about the reservoirs; provide police protection along the line of the work; build certain necessary new sewers in the city of Kingston; and pay indirect and business damages, including salaries and wages to the employees in manufacturing establishments who might be thrown out of work by the carrying out of the project. This legislation was modeled in large measure

upon the statutes of the Commonwealth of Massachusetts, which authorized the work of the Metropolitan Water Board.

The State Water Supply Commission always held that the legislature intended, by the passage of this act, to provide for the general payment of indirect damages in the case of taking of lands for the construction of reservoirs and other structures, and that commission frequently required that the petitioner in any proceeding stipulate that it would pay indirect damages. In the case of municipalities, such a stipulation would be of doubtful force unless the legislature had previously given such municipality authority to pay indirect damages. It does, however, appear that the commission could refuse to grant an application on the grounds that indirect damages should be paid and therefore that the project should not be approved until the legislature had given authority to pay such damages.

Public necessity is a term so broad that many considerations other than those above mentioned could be included under it. The Water Supply Commission held that questions of quality of water could be considered under this head, and in one case rejected an application on the grounds that public necessity for the supplying of water not fit for drinking could not be shown to exist. That consideration was to be given to the quality of the water was indicated by the fact that an eminent authority on sanitation and water analysis was appointed a member of the first commission. Under this head also the question of the safety of the proposed works was considered. At a later date the legislature specifically required determination to be made as to quality of water and safety of works.

A study of the various decisions made by the commission indicates that the availability of a proposed source and the cost of water therefrom were considered proper subjects for study under the head of public necessity. Objections have been made under this head to projects for taking water in order to supply manufacturing industries, and above all to the establishment of competing systems, of which more below.

Since the formation of the State Water Supply Commission, one hundred and ninety-five applications have been filed. Of this number by far the greater part have been approved, and in

most cases of rejection a subsequent modified petition has been made and approved, and the works finally constructed. At times the commission has been criticised because it has rejected so few applications. The number of such rejections cannot be taken as a measure of the value of the work done by the commission. A large percentage of the applications submitted to it are granted only in a modified form, and not infrequently these modifications are so drastic as to constitute a rejection of the original project and the substitution of another in lieu thereof. Such modifications are usually intended to improve the quality of the water proposed to be supplied, as by the installation of filters or other means of purification. Frequently the applicant is required to procure the enactment by the State Department of Health of rules and regulations for the sanitary control of the watershed which it is proposed to use. Modifications are frequently required in the plans to make the proposed works safe and also to make them adequate to perform the service evidently expected of them.

This again brings up the question of provision for payment of damages. It has been held that the commission cannot find that due provision for such payment has been made where it is clear that sufficient funds are not available for the completion of a project. Applications have been denied on these grounds, or have been granted only on condition that sufficient additional appropriations be procured. No projects are considered by the commission unless the construction of the system has been duly authorized by vote or otherwise. Such authorization usually includes the appropriation of the necessary funds. If, thereafter, the commission requires extensive changes and additions, additional funds are usually needed also. It is under such circumstances that the above questions are apt to arise.

To make effective the requirements of the commission, it is necessary to obtain its approval of the completed system before such system may be operated.

Most of the contested cases which have come before the commissions have been applications by a municipality for approval of the installation of a publicly owned water-supply system when the field was already occupied by a private company. In such cases the company usually has argued that public necessity did

not exist for the installation of a competing plant, and that, if such a plant were installed, provision should be made for the payment of damage to the existing company for loss of business. In several cases applications for the installation of such competing systems have been granted, resulting generally in the purchase of the existing system by the municipality. Some duplicate systems have, however, been installed. In these cases the commission seems to have found that the system operated by the company was not giving service or supplying water of quality such that it would be justified in finding that public necessity for a better system did not exist. It has required drastic revision of the plans for the new system in order that it may be certain that an adequate supply of water of suitable quality shall be obtained and that the new system shall be in all respects better than that already installed. This sometimes requires a materially larger expenditure for the new plant than was originally contemplated. The question of the payment of damages to the existing company has never actually been determined.

In all these matters the commission is particularly guided by that section of the statute which requires it in all cases to make a reasonable effort to meet the needs of the applicant.

Curiously enough, although the decisions of the commission are reviewable by the courts and this statute has been in force for ten years, only one decision has ever been argued on appeal and in that case the appeal was dismissed with rather brief consideration.

In forming the Water Supply Commission, the legislature seems to have had in mind that the time had come to initiate steps towards coöperation in the water supply matters, a form of cooperation which is still unknown in this state, although now familiar to everybody in Massachusetts. It was required that the State Water Supply Commission in its first annual report should make a statement concerning the available sources of water supply in the state, the respective purity and quantity of each source of supply, and the availability of each to be used for localities other than those immediately adjacent thereto. The commission was also to report where each municipality at that time got its water, and where and how it disposed of its sewage.

It was also to report the advisability of, the time required for, and the expense incident to, the construction of a state system of water supply, and for a state system for the disposal of sewage. It was manifestly impossible for the State Water Supply Commission in less than a year to make a comprehensive report upon these matters.

In the first and second annual reports issued by that body, the results of a so-called census of water-supply and sewerage systems were published. The commission also reported that it failed to find that necessity existed for a state system of water supply or sewerage at the present time, although it pointed out that there were three areas in the state in which the density of population was such that coöperation in water-supply matters might become advisable. These are: Greater New York and Westchester; the district including Albany, Troy, and Schenectady; the district including and extending north and east of Buffalo. No recommendations were made at that time as to the methods of supplying water to these districts, the commission finding that the matter was unimportant. Events proved that this opinion was not in all respects correct, and the report might well have been different if made at a later date.

During the summer of 1910 a severe drought was experienced in the eastern part of the state of New York, which particularly affected Westchester County. The State Water Supply Commission made a special investigation of this county and its needs for a water supply, and thereafter published an outline of a comprehensive scheme for supplying the entire county by a coöperative system which could obtain water from Peekskill and Popolopen creeks. From these studies it appears that, by coöperation on the lines familiar to the people of Massachusetts, all of Westchester County could be supplied with water of good quality, by gravity, and at a cost probably less than that at which water can be purchased from the city of New York under the provisions of the Board of Water Supply act. More or less interest was shown in this report, but no definite steps have ever been taken to carry out the recommendations of the commission. No settlement has yet been reached in this problem of supplying Westchester County, and it will certainly come up again. The situation there is com-

plicated by the large number of private systems and agitation for municipal ownership.

Some years later it became evident that the municipalities in the district lying between Rochester and Buffalo were insufficiently supplied with water. In this thickly populated district nearly all the systems were taking water from wells and springs. This is a limestone country and the water obtained is all hard and limited in quantity. It is frequently stated that the only running stream in this section is the Erie Canal, the waters of which are not potable. The Conservation Commission discovered that this entire district, including the cities of Tonawanda, North Tonawanda, and Lockport, could be supplied with water by gravity from a single large impounding reservoir on Little Tonawanda Creek south of the city of Batavia. Surveys and estimates on this project were made by the commission in sufficient detail to determine that the scheme was feasible and that the cost of water would be reasonable.

Unfortunately, the coöperative idea was not favored by the numerous municipalities in this district, and no steps were taken to carry the project through. Since that time several of these communities have installed new systems, usually at materially greater expense than would have been required to meet their share of the coöperative scheme.

Studies were later made for a gravity supply for Cohoes, Watervliet, Waterford, and Green Island, communities on the Hudson River just above Albany. It was found that this district readily and cheaply could be supplied with good water and by gravity. Some steps were taken to carry out this project, but nothing has come of it.

Coöperation has not yet succeeded in this state, but it must come. Aside from local jealousy and politics, the chief difficulty has been the method by which funds can be raised for the purpose. If the state could have gone ahead and built the works with state funds, as in Massachusetts, something might have been accomplished. Unfortunately this state cannot by act of legislature appropriate more than one million dollars for any project unless such appropriation has been approved by referendum vote of the whole state. It would be difficult in the extreme to get the people

of the whole state to vote money for the installation of a water-supply system in a small section, even with the provision that the district benefited extinguish the debt thus created.

Provision has been made for the establishment of union water districts, including a certain number of municipalities having more than a certain population. The Conservation Commission may, on application from the municipalities composing such a district, make surveys, plans, and estimates for a water-supply system to supply such district. Estimates of the cost of installing such system may be prepared, and this cost apportioned among the constitutent municipalities. If thereafter each such municipality shall issue bonds in the amount of its share, the system may be constructed and operated by the Conservation Commission. That commission will act only as wholesaler of the water, as the Massachusetts Metropolitan Commission acts. Each constituent municipality will construct its own distribution system and take its water supply off the district mains through a meter.

Activity along these lines may be expected, but not in the immediate future. It is the opinion of the writer of this paper that even now most of the smaller communities along the Erie Canal from Buffalo to Albany could be most economically supplied in this way. That such would be the case in Westchester and elsewhere has already been determined by the commission.

At present New York State determines that the water to be supplied by any new system, or by any existing system from a new source, will be of proper quality. It apportions the water-supply resources of the state, and prevents the construction of unsafe structures in connection with such projects. It determines that proper provision has been made for the payment of damages. It may, under proper conditions, construct and operate coöperative water works. That is as far as we have gone at present.

Neither the Conservation Commission nor any other state board or official can order changes in an existing water-supply system except to make safe such dams as may be connected with it. Even though it be reported by the health authorities and proved by mortality statistics that the water supplied is unfit for domestic use, no state authority can by order compel the puri-

fication of the water or the abandonment of the source of supply. In this respect we have not gone as far as many states.

Although for a good many years we have had public service commissions with authority over transportation corporations, over gas and electric systems, both publicly and privately owned, and similar matters, the state has not yet assumed such jurisdiction over water-works systems. Rates, service, extensions, and the like are not regulated by any state board or official. Here again we have not gone as far as many states.

There has been for some years a demand that the power to regulate the rates and service of water supply systems be given to some state commission. Bills giving such jurisdiction to the public service commissions and to the Conservation Commission have on different occasions been passed by the legislature, but have failed to become law. There seems good reason to suppose that, unless there shall be an abrupt change in public sentiment on such matters, the state of New York will in the not distant future provide for more complete control of public water supplies by some state body.

DISCUSSION.

MR. J. M. DIVEN.* The state of New York has entirely too much legislation and too divided a control of water supplies. By divided control is meant the control by the Conservation Commission, Public Service Commission, State Board of Health, Bureau of Labor Statistics, Bureau of Factory Inspection, and also the Comptroller's Department. As a water-works superintendent in the state of New York, the speaker frequently has to make reports to all of these bodies.

Bills have been before the legislature repeatedly, for the past few years, attempting to place the control either in the Public Service Commission, the Conservation Commission, or the Public Health Board. There seems to be a little strife among these boards as to which shall have this control. The speaker has appeared before legislative committees in favor of each of them; it makes very little difference which one has it, so long as it is

* Superintendent Water Works, Troy, N. Y.

one and only one. The water-works interests of the state will welcome public control; if it is proper control, it will help us in many ways, — in revising our rates, in establishing proper and uniform accounting systems, in securing appropriations for needed improvements, and in control of watersheds or filtration of water supplies. It is also the speaker's belief that it is a matter of sufficient importance to have a separate commission, or at least a separate division of some of the existing commissions, to take charge of sewage disposal and water supply, for sewage disposal and water supply should go hand in hand; they are too intimately connected to be in any way separated.

Speaking of the ninety days' time, our city was short of water last year. The rainfall was very deficient, and one of the sources of supply was short of water, and it was necessary to get water and to get it quickly. We went into the winter without the usual fall rains. The city was fortunate enough to have a reserve supply which had already been approved by the various commissions of the state, which was developed in a matter of a few days, tiding over our difficulties and giving the particular section in serious need a water supply through the winter. If we had not owned this supply, and had had to go to the Conservation Commission for permission to acquire or use it, and had waited ninety days, held hearings, and operated all the other machinery provided by the law, a large section of the city would have been without water during those ninety days. The supply was turned into the city mains just about forty-eight hours before the existing supply would have been exhausted.

Mr. Morris Knowles.* The author deserves our thanks for calling attention to one of the features of the large conservation movement which is so important and which is becoming of more and more consequence as the country grows and our population becomes more congested. The feature of the paper in which it is mentioned that there is need of apportionment of water resources is certainly one of moment, and one that all should consider. For it does not seem fair that the first company or city in a district should have the right to "prior appropriation," as it is called

* Civil Engineer, Pittsburgh, Pa.

in the West, because that may bring about inequitable distribution of the water supplies of the state. There should be some central authority which shall look ahead into the future and study the possible growth of communities and the possible yields of various watersheds, and then apportion them in such a way that there shall be justice and fairness. That seems certainly a proper step in advance, and one that all states should emulate.

I was particularly struck with another portion of the paper, which referred to the fact that the commission in New York sometimes considers the need of giving permission to build competing systems. It seemed to me wholly inexplicable why such an emergency should arise. But a little later, and toward the close of the paper, we find the solution, namely, that while there is machinery in the state to govern the character of the water-supply service, as it affects the public health, there seems to be no provision now in the state of New York to govern or control the questions of adequacy and completeness of service, and fairness of rates of water companies, and those matters which do not affect the public health. These seem to be lacking; therefore, does it not suggest that if the state of New York had that sort of machinery there is absolutely no need for the duplication of capital, no reason for having a new investment and causing an old investment to become worthless? Is it not rather the better thing to compel the company, or whatever may be the corporate form of the agency, to give that service in a complete way and at just and equitable rates, and thus do away with the duplication of capital investment?

I was much impressed with the latter part of the paper, too, which referred to the subject of coöperation. We have, as the author points out, that very fine illustration in the state of Massachusetts, where cities and towns seem to be able to get together, possibly not wholly from their own volition originally, but at least finally they were brought together, — and that sort of machinery is going to come, it seems to me, to be the thing in our country as the cities and towns grow, population becomes more and more congested, and it becomes necessary to deal fairly with these various communities, one with another. It is going to become necessary that peoples of different areas and views shall

sit down around the table, get together, and have metropolitan districts for various purposes.

While it may not be particularly germane to a water-supply association, I do want to call attention to the fact that this subject is simply one of the phases of the large movement of conservation, and that the streams of our country have many uses and that the water supply is not the only use. They even have that very humble use for the dilution of sewage in many cases, and they have the use for power, and the use for navigation, and the use for irrigation. So, when we are thinking of this movement of co-operation, we should think of it from a still larger and broader point of view, namely, to get out all the utilization that there is in running water for the several uses of different peoples and under different circumstances.

MR. G. L. WATTERS. Mr. President, I should like to ask the author whether the act which gives the powers under which the Conservation Commission acts is at all similar to that in Pennsylvania which gives the Water Supply Commission of that state the right to pass upon the plans of any dam or any obstruction in a stream within that state, whether that obstruction is made for the use of public-water supply or whether it is made by an individual for an ice pond or by a large corporation which will procure its own water supply.

MR. SUTER. In this paper I have not attempted to cover all the engineering work of the Conservation Commission. We have jurisdiction over all the dams in the state that do not qualify as being less than ten feet high, on a watershed of less than a square mile, and impounding less than a million gallons of water. As that law was first passed, it applied to any dam on a stream, the minimum flow of which was greater than a certain amount, but that was too hard a criterion to apply, and it had to be revised. We have the right to inquire into the condition of existing dams, and have to pass on all plans, both for new dams and for the reconstruction of old dams, no matter what the purpose of the dam. We consider only the safety of the structure. It has nothing to do with the use of the stream at all.

I would like to state that that ninety-days' provision mentioned by Mr. Diven, I assume, was added for the protection of the

applicant, to keep the matter from being held up indefinitely. As a matter of fact, the Conservation Commission endeavors to enter a decision as promptly as possible. A certain amount of time of course has to be taken in any red-tape operation. The law requires us to hold a hearing and to publish a notice of that hearing in the newspapers. The newspapers in the smaller towns are published weekly, so that it takes a certain time to get started. After that we have to prepare our decision. I have known of a decision being prepared within an hour and a half after the termination of the hearing.

In regard to competition, Mr. Knowles hit upon and very happily expressed the reason why the commission has granted permission for the establishment of competing systems. When a municipality makes an application to install a water-supply system, and proves that the private system already in operation has pipes that will hold only twenty pounds' pressure, are too small to give fire protection, and there is not enough water any way, the pipes are dry a good part of the time, and when they have water it is bad, considering that the state has no power to require any changes whatsoever in that system, the Conservation Commission has been unable to find that public necessity did not exist for a good, adequate system for furnishing water, and has granted applications on that consideration. If the commission had been able to tell the existing company to do this, that or the other, and make it do it as it ought to have the power to do, it might be different. Of course I do not imagine that any of us really believe in the duplication of a proper water-supply system with the resulting loss of invested capital.

MR. WATTERS. May I ask if it is necessary for any individual, corporation, or municipality to make application to the Conservation Commission before beginning the work of constructing a dam or any obstruction in a stream, supposing it to come within those requirements of ten feet and one square mile and so on, and is there a penalty if it is not done?

MR. SUTER. Yes, it is necessary, and there is a penalty if it is not done.

THE LOCATION OF LEAKS IN SUBMARINE PIPE LINES.

BY ELMER G. HOOPER, ASSISTANT ENGINEER, DEPARTMENT OF WATER SUPPLY, GAS, AND ELECTRICITY, NEW YORK.

[*Read September 7, 1915.*]

In connection with the maintenance of the distribution system of a large seaboard city, a great many varied problems arise, some of which require special treatment. One among them is the detection and location of leaks on submarine pipe lines supplying islands or areas isolated from the main system by rivers or channels.

Detection of leakage on such lines is comparatively simple, but the location of them is an entirely different matter. Any of the usual means of measurement fitted for the size of main, with perhaps special arrangement for large mains, will determine the presence and size of leak if simultaneous readings are taken on both sides of the stream.

Several points should be noted which have a bearing on the problem of leak location and which affect the method to be used for such location. Owing to the expense attached to the examination and repair of submarine pipe, it is not worth while to do anything with them unless the amount of water going to waste is worth more than the probable expense, or the pressures in the area supplied are materially reduced, or serious damage is anticipated from a continuation of the leakage.

In general, the above considerations would limit the complete investigation to leaks of such size as would make applicable the following method, which has been used in New York City on a 12-in. crossing from Rikers Island to North Brothers Island, and is considered sufficiently successful to warrant making preparations for its use on other river crossings.

Where the velocity of water in a main due to the leak is two feet per second, a perfectly good gradient consisting of two distinct slopes can be obtained. At the point where the slope of gradient changes, is the point where the velocity changes and hence where the waste occurs.

To determine this gradient it is necessary to have the pipe coefficient as accurately as possible, to have the flow at the supply and the discharge ends of the submarine pipe, the pressures, and elevations at which pressures were taken on both ends, and the distance between pressure points. Flow measurements and pressures ought to be taken simultaneously. Pressure gages should be accurate and of such graduation as to easily estimate to tenths of pounds.

The specific case of the above-mentioned crossing between Rikers and North Brothers Island will best illustrate the method.

Some time during the month of July, 1914, a decided drop in pressure on North Brothers Island was reported to the department and an urgent request made to have conditions improved. The district repair gang found after valve operation that the trouble was on the 12-in. crossing from Rikers Island to North Brothers Island, this stretch of pipe being a section of a loop from the mainland at Barretto Point to Rikers Island to North Brothers Island and on through a 6-in. to the mainland at 140th Street. Orders were issued to the Water Waste Division to determine, if possible, the location of the break, because North Brothers Island with its hospitals was under these conditions dependent upon the one inadequate 6-in. line. A party was sent out at once and carried through the investigation with satisfactory results in a couple of days.

As no pipe coefficient was available, it was necessary to determine one for a line of similar size and under similar conditions. It was obtained at Barretto Point on the Rikers Island line. With the valve closed on the North Brothers Island end of the broken line, a pitometer placed in the 12-in. line at Barretto Point measured the leakage plus the Rikers Island consumption, then, with valve on the Rikers Island end of the broken main closed, measured the island consumption alone. The difference gave the leakage for that height of tide. As soon as possible, then, pressures were taken simultaneously on hydrants located near each end of the flexible pipe. Hydrant elevations and distance were obtained by level and transit respectively, distance being checked roughly from a government chart. The coefficient in Chezy formula was then determined for the Barretto Point section where a flow was con-

stant throughout its length. Applying the pipe coefficient to the broken section, the slope of the gradient up to the leak was found. Since the valve at the North Brothers Island had been closed, there was no flow beyond the leak, hence a flat gradient obtained from the leak to that point. After figuring the gradient elevation at each hydrant and plotting the gradient to scale, the distance of the leak from the hydrant at North Brothers Island was determined as approximately six hundred feet.

To check the figures an attempt was made to find the leak by sound. An engineer using an aquaphone with an oar placed in the water was taken in a boat and by means of stadia and transit directed to the point near where leak was supposed to be. The sound could be distinctly heard even though the depth was about twenty-five feet. On a circumference of one hundred foot radius, approximately, the sound became indistinct. As found by the diver, the break was 570 ft. instead of 600.

It is possible, we believe, to locate such leaks at least as closely as within thirty feet, and often closer, if pipe coefficient is accurately determined for each crossing and corrected every few years as the pipe ages.

TESTING METERS WITH REFERENCE TO CURVES OF ACCURACY AND FRICTION LOSS.

BY FRED B. NELSON, ASSISTANT ENGINEER, DEPARTMENT OF WATER SUPPLY, GAS, AND ELECTRICITY, NEW YORK.

[*Read September 8, 1915.*]

The New York Water Department is now making investigations looking toward more scientific and definite requirements in regard to meters, including the practicability of specifications on material and design; the establishment of a definite rate basis for testing meters to replace the present vague size-of-stream method, with that representing reasonable requirements; and the inclusion, in approval tests, of the determination of the curve of pressure loss at varying rates of flow as having an important bearing on the general efficiency, service, and durability of the design.

The writer feels that it would be out of place at this time to go into detail as to the methods to be adopted to meet the New York conditions as an outcome of this investigation, but desires rather to call attention to one or two features, more or less general, in present meter-testing procedure which it is hoped may be improved in fairness to the consumer, the municipality, and the meter companies.

The matter of specifications for meters is one which, if taken up at all, requires long and careful study in order to write specifications which will definitely *specify* without interfering with a desirable exercise of resourcefulness in design by the meter companies, backed by their experience in meeting and overcoming difficulties.

The testing of meters on a rate basis it is believed will meet with the general approval and preference of all concerned as being a definite, intelligible method, as against the haphazard size-of-stream procedure, a true conception of which can only be gained by an attempt to determine the rates corresponding to the various sizes of streams being used as per schedule. Such a determination has been included in the course of the investigations in this city,

from which it is learned that the variation, especially on field tests, is too great to represent anything like uniform testing, the wide range in rates being, of course, due to variation in street main pressure, size and interior condition of service pipes, friction loss in meters of the same size but of different makes and conditions, variation in length, size, and layout of hose and fittings from a meter in place to the test meter on different tests, etc.

A rate schedule should be made up with reference to the char-

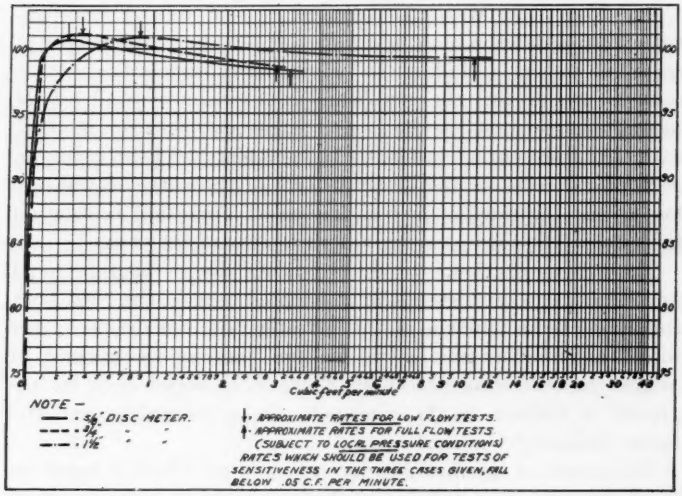


FIG. 1.

Typical accuracy curves for disk meters illustrating rates at which tests should be made to define the curve of the individuall meter.

acteristic accuracy curve of the individual size and type of meter. Such a curve for disk meters (Fig. 1) rises abruptly from a low registration at the minimum operating flow to a maximum at low flow. From this point the per cent. of registration for nearly all makes of meters decreases slightly as the rate increases to a point at maximum rate which may be one or two per cent. below the maximum registration. The accuracy curve of a meter may be defined by a test that includes the two rates, — one at the point

of maximum registration and the other at full flow. There should then be included in the test a third rate — constituting a test of sensitiveness — at which a meter in proper condition should operate.

When a rate schedule is established, it is proposed to control the rate on field tests by means of an apparatus including in general a set of calibrated orifices through which the water may be discharged under a difference of pressure shown by attached gages and regulated by a throttle valve, the size of orifice being selected by the operator with reference to the rate desired, the plotted or tabulated discharge of the orifices at varying pressure, and the available static pressure. With the rate thus adjusted, a test would be started and stopped with a cut-off valve in the ordinary way.

The question of pressure loss in a meter is one which is ordinarily considered as of secondary importance, accuracy being the accepted prime requisite of the apparatus. It would seem, however, in this age of efficiency and economy, that, other things being equal, preference should be given to the measuring device which consumes, for operation, the least amount of the pressure energy which the pumping station supplies and the system is designed to conserve. On the ordinary service, the meter usually consumes approximately from 25 per cent. on small sizes to 90 per cent. on large sizes of the total loss on the service. The pressure loss due to the meter is, therefore, an item of the total loss and one to be equally considered with that of size of tap and service.

An apparatus so constructed that the water in passing through will displace a well-fitted piston or disk with the motion of the latter transmitted to a registering dial might of necessity constitute a measuring device that would meet the requirements of the ordinary accuracy test. A water meter, however, that combines a high degree of sensitiveness, durability, and accuracy with a minimum of pressure consumed in operation requires careful and expensive investigation, design, and manufacture.

The feature of pressure loss is one that is tangible, easily determined, and definitely comparable with fixed standards, and as one which affects the consumer and the water department, it should be considered in approval tests, and the efforts of the meter

companies in perfecting their design to meet high standards should thereby be recognized.

The ignoring of friction loss or its reciprocal feature — capacity — has resulted in the low capacity meter gotten out in inferior sizes by the meter companies to meet the competition under requirements which have included accuracy only. In the case of 2-in. disk meters recently investigated by the New York department, it was found that 75 per cent. of the 2-in. meters being delivered to consumers were of the low capacity type, and inquiry in six cases at random showed that the purchaser had no knowledge of high and low capacity, simply specifying 2-in. meter and taking what his plumber delivered. In one of these cases the complaint of low pressure called for an investigation by the department, which revealed the fact that two 2-in. low capacity meters set in parallel were responsible for a drop of 6 lb. in pressure at the time of maximum draft. This loss could have been reduced to only 2 lb. under the same rate had full capacity meters been installed, which would

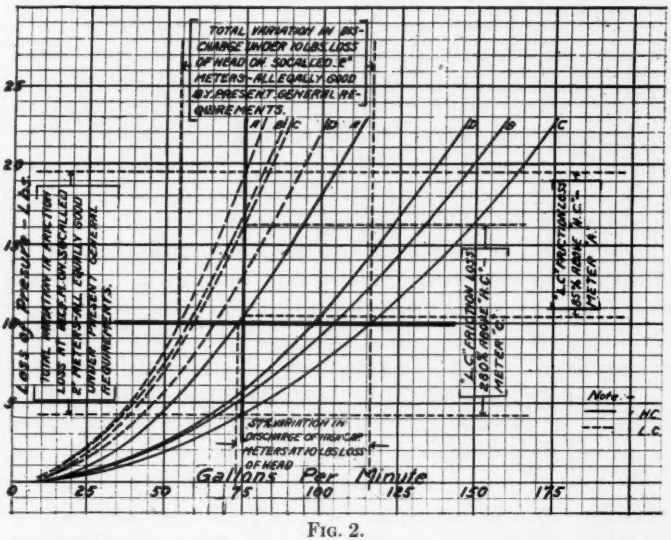


FIG. 2.

Comparative loss of pressure and capacity. Four makes of "high capacity" and "low capacity" 2-in. meters.

have obviated complaint and saved investigation; or, conversely, full capacity meters under the same loss of head in the meter would have delivered nearly twice the existing maximum draft.

In regard to the question of capacity, tests were made to determine curves of friction loss at varying rates of flow on high and low capacity 2-in. meters and 1½-in. meters of those makes which included two capacities of the one size.

These tests showed a friction loss in the low capacity meters (Fig. 2) varying from 85 per cent. to 280 per cent. above that in the high capacity, the discharges under 10 lb. loss of head on the high capacity being from 35 per cent. to 90 per cent. above the low capacity, while the discharge of the different makes of the 2-in. full capacity type varied by as high as 57 per cent. Curves of friction loss determined on other meters show a wide variation between different makes in the same size and type.

Comparing the data furnished by the meter companies as to capacity of disk meters (Fig. 3) it may be noted that under a 10-lb. loss of head the variation of discharge on the same sizes of different makes is as high as 97 per cent., and averages 64 per cent.

On fire line meters and compound meters the curve of friction loss is also a guide as to the rates which should be used in testing. The curve usually shows a " change point " at a low rate — somewhat subject to pressure conditions. At this point a fluctuation in pressure loss and accuracy is to be expected, and this rate should be avoided in the test. The rates used should be those schedules for each of the meters included in the design.

In connection with the recent investigations along these lines, a number of tests have been made to determine curves of accuracy and friction loss, in all of which the procedure and apparatus used has been essentially the same. The rates were obtained by actual weight of the quantity of water passed, the time being determined by stop-watch. The loss of pressure was determined by measurement of the deflection of mercury in a 6-ft. U-tube connected by rubber tubing to 8-in. sections of the testing machine above and below the meter. The pressure loss was computed from the deflection of mercury, using mercury at a specific gravity of 13.6 minus 1 for the equal column of water in the other leg of the tube. The mercury U-tube gives very consistent results, eliminates

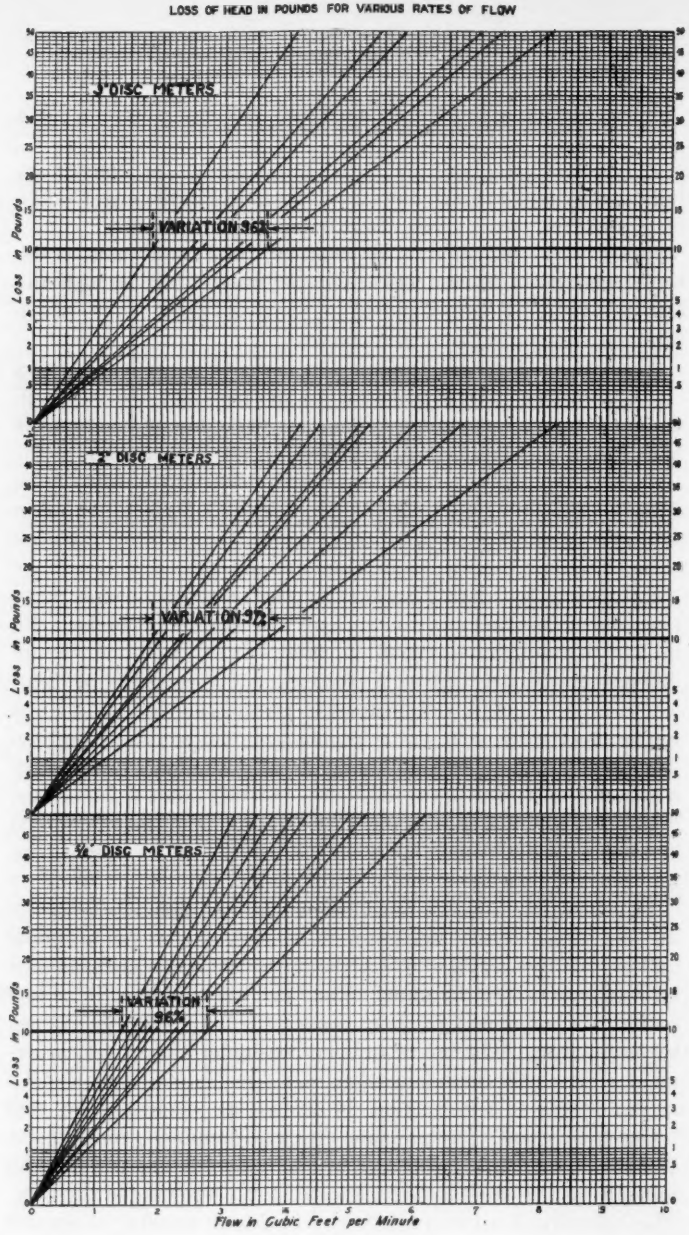


FIG. 3.

Illustrations of variations in discharge on different makes of meters of corresponding sizes under pressure loss of 10 lbs. (Taken from data supplied by individual companies.)

gage errors and errors due to attempts to compare and subtract the simultaneous readings of two gages, and has an especial advantage on low friction loss, as $\frac{1}{16}$-in. or $\frac{1}{8}$-in. deflection is very definite, while the corresponding .3 or .6 lb. of pressure difference would be indeterminate with ordinary pressure gages. The 6-ft. length of tube is sufficient for measurement of pressure differences up to 32 lb.

THE BROOKLYN WATER SUPPLY.

BY WILLIAM F. LAASE, ASSISTANT ENGINEER, DEPARTMENT OF WATER SUPPLY, GAS, AND ELECTRICITY, NEW YORK CITY.

[*Read September 8, 1915.*]

The catchment area from which Brooklyn derives its water supply is located along approximately the southerly half of Long Island, extending from Gravesend to the Suffolk County line, or a distance of about 35 miles, and from about one-half mile north of the southerly shore line to the summit of the ground-water table, which is located a short distance to the south of the ground surface divide or backbone of the island. The watershed area within these limits comprises about 200 square miles. The underlying strata are mainly of coarse sands and gravel several hundred feet in depth with one or more intermediate clay beds.

The rainfall percolates slowly downward through the sands to the saturated sand bed, and thence generally southerly toward the bays or ocean along the south shore. There is also a comparatively small flow of the ground water into the streams which during rainfall periods receive direct accessions from the rain. This slow-moving body of water has a downward slope of about 12 ft. per mile in a southerly direction from the ground-water summit, and its upper surface is commonly referred to as the "ground-water table."

The collection system is located in the southerly portion of the catchment area, about one-half mile north of its southerly limit; practically the entire ground-water flow and stream flow is thereby intercepted.

Ten surface streams are utilized, of which number eight flow by gravity into the conduit system and two are pumped. In addition, there is one storage reservoir with a content of about 880 million gallons, which furnishes a gravity supply into the conduit system and which is held in reserve. Twenty-seven pumping stations obtain their supply from the ground-water flow, of which number twenty-five are driven well stations and two are infiltra-

tion galleries. Four of these stations deliver their supply directly into the distribution system and twenty-three deliver into the conduit system. All water delivered into the conduit system is pumped into high-level reservoirs, from which it flows into the distribution system.

There are about 975 wells, varying in depth from about 30 ft. to about 325 ft., and in size from 4.5 in. to 24 in. In general, the wells are of the iron-pipe type with solid brass strainers. Some are of the slotted vitrified pipe type, varying in diameter from 6 in. to 18 in., with a maximum depth of about 50 ft. The wells deeper than 90 ft. penetrate one or more blue clay beds and they are driven by means of a well driving machine; after the pipe has been driven to the depth desired, about 20 ft. of brass strainer with a short length of plain brass pipe and lead packer at the top is lowered into the hole; the casing is then pulled back, thereby leaving the strainer exposed to the water-bearing sand and gravel; the lead packer is then expanded, thereby sealing the annular spaces between the strainer and the outer casing. Many of the shallow wells are also of the iron-pipe type with solid brass strainers; these wells are placed by sinking larger casing to the desired depth, by the weight and bucket method; after all material is removed from within, the strainer with pipe attached is lowered; then as the larger casing is withdrawn, the annular space is graveled.

The two infiltration galleries have a total length of about 6 miles, and are composed of vitrified pipe with socket, in 3-ft. lengths, varying in size from 20 in. to 36 in. The pipes are laid with open joints about 10 ft. below the ground-water table to a grade of .04 in 100 ft. toward a central pump well, located about midway in each gallery, from which the water is pumped into the conduit system.

Owing to the water waste campaign during the past three years, it has been possible to discontinue the use of six driven well stations and one stream of those previously mentioned, representing a saving of about 18 million gallons daily, and to furnish about 7 million gallons daily to the borough of Queens from the remaining sources of supply.

The following shows the actual average cost of the wells based on materials, and teams for hauling same from headquarters to

site of work, exclusive of overhead charges, laborers at $2.50 per day of eight hours.

8-inch deep well, 200 ft. deep	$3.07 per foot
6-inch shallow well, 60 ft. deep	4.71 per foot
8-inch vitrified well, 50 ft. deep	2.82 per foot
12-inch vitrified well, 25 ft. deep	7.00 per foot

The first two are of wrought-iron pipe with 20 ft. of brass strainer.

DISCUSSION.

MR. ALEXANDER POTTER.* The procuring of water supplies by means of infiltration galleries is not commonly resorted to. Even where the use of infiltration galleries promises to yield good results, engineers often hesitate to make use of them because of the many failures recorded, the causes for which either are not understood or when understood have not been brought to the attention of the engineering profession.

The proper design of an infiltration gallery should not be at all difficult, for the process which takes place in an infiltration gallery is duplicated in nature by the diffused seepage of the underground waters into surface streams. This ground-water seepage maintains the flow in surface streams long after the direct effects of the rainfall have ceased. The fundamental laws governing the ground-water flow of surface streams are fairly well understood and apply with slight modifications to infiltration galleries. They may be stated as follows:

1. The ground-water stream flow is fixed and limited to the surplus underground waters accumulating and stored in the valley.
2. The rate of seepage varies with the transverse hydraulic slope of the ground-water table and the porosity of the material through which the ground water flows.
3. When the hydraulic slope is not steep enough to discharge the surplus ground waters as fast as they collect in the valley, the ground-water table rises until equilibrium is established, and vice versa if opposite conditions exist.
4. Except as affected by the seasonal changes of the rising and lowering of the ground-water level, the ground-water stream flow is constant.

* Consulting Engineer, New York City.

There is no reason why the seepage of ground water into an infiltration gallery under proper conditions should not be equally as dependable as the identical natural process of ground-water seepage into surface streams.

An infiltration gallery may derive its supply of water from two distinct sources: A supply derived by intercepting the surface underground waters which were under natural conditions joining the surface waters by diffused seepage, and a supply derived by infiltration from bodies of surface waters adjacent to the infiltration gallery. It appears that many infiltration galleries derive by far the larger portion of their supply from the second source. A carefully made scientific investigation will in nearly every case reveal within quite narrow limits the quantity of water available for an infiltration gallery from the two sources above mentioned, and as long as the draft does not exceed the available supply there is no reason why the yield of a properly designed infiltration gallery should gradually decrease with time, as is only too often the case. The recorded failures of infiltration galleries can, in the writer's opinion, be largely attributed to the erroneous assumption that a pipe laid below water level with open joints or perforations and surrounded by a porous material will continue to deliver the volume of flow developed when first constructed, ignoring entirely the fundamental law of supply and demand.

This is not true with infiltration galleries constructed on the floor of an impervious strata intercepting the transverse ground-water flow in a pervious strata of coarse sand immediately above. Under such conditions, infiltration galleries have been very successful. A typical example of such a gallery is the one constructed at Munich, Germany.

Under conditions other than that just stated, and where the supply appears to be adequate, there is often noted a gradual breaking down of the infiltration gallery, apparently due to the silting up of the filter media immediately surrounding the gallery. Under the natural conditions of ground-water seepage into surface streams, no such silting appears to take place, and when such silting up occurs in connection with an infiltration gallery, it can only be due to the peculiar ground-water conditions set up by construction of the gallery. The writer believes that the silting

phenomena are primarily due to the high velocities of the ground water through the filter media immediately adjacent to the gallery, velocities so great that the finer particles of soil are transported to the gallery, gradually clogging the interstices in the filtering media and the gallery proper. This phenomenon of clogging is aggravated by the lowering of the ground-water level in the vicinity of the filter gallery below the top of the gallery. For a definite yield, as the wetted perimeter of the gallery decreases, the entrance velocity increases in inverse proportion. To attempt, therefore, to force an infiltration gallery to the extent of lowering the ground-water table below the top of the gallery, will tend to increase the danger from clogging and materially shorten the life of the infiltration gallery, especially when constructed in the finer sands.

With tubular wells, the question of high entrance velocity in the filtering media surrounding the well screen is not of equal importance; wells are comparatively short-lived, and when clogging does occur it can be remedied by back-flushing or other known methods. No such remedies are available for clogged infiltration galleries. When properly designed so that the yield of the gallery does not exceed the supply available from the surplus underground waters and the supply derived by infiltration from a nearby body of surface water, and the entrance velocities are sufficiently low so as not to transport the finest soil particle, the useful life of the infiltration gallery should be practically unlimited.

The yield from an infiltration gallery constructed in the finer sands should be automatically controlled so that it cannot exceed a certain predetermined amount, in order to prevent the lowering of the ground-water plane below the top of the gallery, so as to keep the entrance velocities within safe limits. This condition can best be secured by restricting the flow from the gallery to an amount which will keep the gallery constantly full of water for its entire length.

In many cases the requirements as outlined herein will for a given yield call for the construction of much longer lines of infiltration galleries, constructed in finer sands than has been the practice in the past, so that in many instances other methods

of supply will be found to be more economical. Throughout the country, however, deposits of gravel and sand exist in the valleys of rivers and along lakes and seacoasts, in which infiltration galleries can be economically constructed to yield adequate supplies either from the surplus underground waters or from the water derived by infiltration from adjacent natural and artificial bodies of water, or from both sources. The successful results on Long Island show the maximum possibility of such a supply.

In tropical countries, where there exists so strong a prejudice against the use of stored surface water for a public water supply, due to the deterioration resulting from the luxuriant vegetable growth abounding in such waters, the use of an infiltration gallery is often advisable. The natural purification which takes place in the water while passing from the surface reservoir to the infiltration gallery has been found to be effective. The ability to economically produce a good, clean potable supply even from a very inferior raw water by double filtration, or by other methods, has not been generally recognized. It appears that ground waters are largely preferred, and the proper use of infiltration galleries alone or as a supplement to a well supply is an important matter.

MR. WALTER E. SPEAR.* Some seven or eight years ago, when the Board of Water Supply of New York City was investigating the possibilities of developing a large ground-water supply in Suffolk County, Long Island, I had occasion to look into the Wantagh and Massapequa infiltration galleries of the Brooklyn works which Mr. Laase has described, and I am very glad to confirm his statements of the success of these works. The geologic conditions where these galleries were built were very favorable for this type of construction. The uniform yellow gravels, which carry most of the southerly flowing ground water, have there but little depth, and the gray sands and clays beneath are practically impervious, conditions favorable to the collection of a supply by means of galleries which cannot be economically constructed far below the ground-water surface. These galleries were necessarily built on land previously purchased for other purposes and were, therefore, located rather close to the salt waters of the south

* New York.

shore of Long Island. Heavy pumping from wells on the same location might have drawn in salt water, but the galleries, placed as they were, not far below sea level, were entirely safe from such infiltration. Another favorable circumstance is the absence of much iron. I think the Department of Water Supply has had no trouble from clogging of the galleries due to this cause. In Europe such trouble has occurred, and I know of several instances where the galleries have given place to wells.

One serious objection to the infiltration gallery is that it does not provide any storage if constructed, as were these galleries, at an economical depth below the ground-water surface. The normal depth of the water over the Wantagh and Massapequa galleries is something like 10 or 15 ft., which is diminished rapidly as soon as any draft occurs. After the water is drawn down within a few feet of these galleries, but little storage is left to draw upon. On the other hand, in a water-bearing formation of some depth, favorable to well development, a well can readily be driven such a depth that by pumping down the ground water a large amount of storage becomes available. Such conditions are not found where the Wantagh and Massapequa galleries are constructed, but farther east on Long Island, in Suffolk County, good material is found to a depth of 100 ft. or more, and the possibilities of developing ground-water storage are great. In that district it would be a serious mistake, for the reason just given, to construct infiltration galleries. As for the comparative cost of water from a system of wells and from infiltration galleries, the greater cost of operating the wells largely offsets the much larger first cost of constructing the galleries. Considering a well-designed gallery permitting access for inspection or repairs, the advantage in cost of these supplies is in favor of the wells.

Mr. Laase (*by letter*). The writer offers his apology for his very meager paper, for it was not his intention to go deeply into the subject because of the lateness of the hour. He extends his thanks to Messrs. Potter and Spear for their opportune discussion. He would, however, like to add that on the Brooklyn watershed, west of Rockville Centre, where there are only driven wells, the unit yield per square mile of watershed area is almost double that where there are only infiltration galleries east of Rockville Centre.

This is necessarily so because the galleries merely intercept the ground-water flow above the first clay bed, which is approximately 40 or 50 ft. below the surface of the ground at the gallery, whereas the wells which penetrate one or more clay beds intercept the flow of a greater depth. There can be no doubt, then, that with long, well-designed suction lines and a sufficient number of wells connected thereto, more water will be obtained than through the infiltration gallery of the same length; and it is believed that the well system will be the more economical in the end.

GRUBBING A LARGE RESERVOIR.

BY GEORGE A. WINSOR, M.AM.SOC.C.E.

[*Read by title, September 9, 1915.*]

Early in August, 1914, work was commenced grubbing around the shores of Kensico Reservoir, a part of New York City's new Catskill water supply. The land taken for this reservoir comprises some 4 470 acres, and as the water will cover about 2 218 acres, there will be marginal lands of about 2 252 acres. The contractor is required to clear the site of the reservoir to a line 30 ft. outside of the flow line, which is about twenty-seven miles in length.

Under the specifications, grubbing shall include all designated areas within the 30-ft. margin of the reservoir, the reservoir bottom wherever the depth below the flow line is 35 ft. or less, and other areas wherever ordered. The grubbing consisted of the removal of all stumps and roots larger than 2 in. in diameter to a depth of 6 in. below the surface of the ground, and all holes left after grubbing the margins of the reservoir and its bottom to a depth of 10 ft. below the flow line had to be satisfactorily refilled. The areas paid for were the designated areas grubbed, except that no area could be estimated for payment as having a less area than 1 000 sq. ft., or a less width than 20 ft.

All areas to be grubbed were designated on the ground by actually staking them out in advance of the work as follows: The limit of clearing was staked by measuring 30 ft. horizontally above the flow line at elevation 355; then the elevation 320 contour 35 ft. below the flow line was staked, and with these lines marked on the ground the field party was able to locate most areas with a tape only so they could be platted in the field on the topographic plans, 100 ft. to the inch scale, with the additional information already on these plans, such as boundary walls, highways, building foundations, fences, water courses, etc.; if there were no natural features which could be identified in the maps, the area was located by stadia and subsequently plotted.

The principal natural timber growths around the basin consist of oak, maple, whitewood, birch, hickory, elm, locust, ash, dogwood, cedar, chestnut, and many fruit trees of different kinds. The chestnuts had been killed by the "bark disease."

Most of the clearing on the areas to be grubbed was done during the years 1910 and 1911, and the stumps of the trees were cut off close to the ground; for this reason the old method of pulling the stumps with a stump puller of capstan type, pulling the stump with the tree as a lever, using a block and fall, or the use of the caterpillar traction engine as used at Ashokan Reservoir, were not adapted to the work here.

The grubbing was sublet by the reservoir contractor, and a portion of it was again sublet. The method employed by the subcontractors was as follows: All small stumps from 2 in. to about 5 in. in diameter were grubbed by hand, using axes and mattocks, and all sprouts were cut off of the larger stumps, which were then removed with the aid of an explosive. Sixty per cent. dynamite was used most of the time, the quantity depending upon the size of the stump, variety of tree, and the quality of soil around the roots.

Many areas covered with a thick growth of small locusts were encountered; these were pulled with a pair of horses or yoke of oxen with a chain hitched around the tree; usually a little grubbing was done on one side only. This proved to be a very effective and rapid method for removing this species of trees when not too large.

The contractor usually worked about three weeks after a monthly estimate on the grubbing and blasting, as he found it required the remainder of the month to clean up and burn the brush and stumps before his next succeeding monthly estimate.

Work was carried on through the winter months with very little interruption, it being a very mild winter with but little snow; during the spring months, which were very dry, the contractor was forbidden building fires because of the fire hazard to city property adjacent to the clearing limits. He continued with the grubbing operations and burned the stumps later when the grass was green and the weather suitable.

The grubbing was practically completed in August, 1915, thus

requiring thirteen working months to grub a total of 502 acres. The maximum amount grubbed in a month was 70 acres, in the month of June, 1915; the average amount grubbed per month was 39 acres, but the quantity of labor varied during the progress of the work.

A daily record was kept of the dynamite used by the contractors for the estimate months, and the quantities used per acre have been computed and may be of interest:

Maximum dynamite used, September, 1914	170 lb. per acre
Minimum dynamite used, January, 1915	44 lb. per acre
Average dynamite used, for entire work	95 lb. per acre

The largest timber growth in the basin was grubbed during the month of September, 1914, as indicated by the quantity of explosive used, while during the month of January, 1915, small stumps were grubbed.

It was further demonstrated that it required less explosive to shatter a stump when the ground was frozen than when there was no frost. In the former case very little earth was disturbed by the blast, while in the latter case a large hole was made. A hole was made in the ground with an iron bar, and the explosive was placed under the stump; fuse exploders were always used.

The contract price for grubbing, which included refilling holes, disposing of stumps and brush, and all expenses incidental to the work, was $100 per acre.

In conclusion, the writer believes that the method employed in doing this work was the most economical and the best, under the circumstances. However, had it been possible to do the clearing and grubbing in one operation, the latter would have cost the contractor less, as there would be a considerable saving in both labor and explosive if one of the other mentioned methods had been employed.

LEADITE JOINTS FOR WATER PIPES.

BY HENRY A. SYMONDS, CONSULTING ENGINEER WITH HANSCOM CONSTRUCTION COMPANY, BOSTON, MASS.

[*Read September 7, 1915.*]

The use of Leadite for pipe joints seems to have been attended with widely conflicting experiences. Many of the contractors and town and city water departments have met with disappointing results in its use, while, on the other hand, it has a large number of enthusiastic advocates.

The writer knows of no way to handle the subject except by cumulative testimony of actual experiences, and wishes to acknowledge receipt of valuable information relative to Leadite from Mr. George McKay, Jr., of the Leadite Company; Mr. C. P. Cook, Dover, N. J., Water Department; Mr. Frank A. Marston of the firm of Metcalf & Eddy, consulting engineers; Mr. Harry C. Lyons, deputy water commissioner, Department of Public Works, Buffalo, N. Y.; Mr. Lincoln Van Gilder, superintendent water works, Atlantic City, N. J.; Mr. W. C. Hawley, chief engineer and general superintendent Pennsylvania Water Company; Mr. John Palmer, general contractor, Boston, Mass.; and Mr. H. E. Aherns, of the Reading Contracting Company.

Leadite was tested by the manufacturers in the ten years from 1894–1904, and the company, being satisfied that it had finally perfected the process of manufacture and the proper composition, put it upon the market in the latter part of 1904.

The first actual use of Leadite in public works is reported by Mr. Lincoln Van Gilder, it being used by Mr. Kenneth Allen, superintendent Atlantic City water works, in 1903, and its use has been continued by Mr. Van Gilder with very favorable results up to the present time. No sign of deterioration has appeared in any instance in that city, and the joints seem to be uniformly watertight. To quote Mr. Van Gilder further:

"The percentage of bad joints compare very favorable with

lead under the best conditions, and with close or wet joints the difference is decidedly in favor of Leadite."

Used in Atlantic City in sandy soil, much of it below ground water, Leadite worked very favorably in the wet ground where molten lead could not be used. Seepage was noted in the newly poured joints, but this entirely disappeared in a few days.

Mr. C. P. Cook used Leadite first in 1907, and has used it continuously since that time in the Dover, N. J., water works, under pressures varying from 20 to 180 lb., without having had a bad joint and no signs of deterioration.

The experience of Metcalf & Eddy, who were among the early water-works men in New England to become interested in Leadite, is well outlined in the following letter:

" Leadite was used on construction work under our supervision for the first time in 1909, at Concord, Mass., on the Nagog Pond 16-in. pipe line. In this contract it was optional with the contractor whether lead or Leadite should be used, and the contractor chose the latter as offering some advantages on account of the wet character of the ground through which the pipe was laid for a considerable distance. The specifications stated in considerable detail the method to be used in handling the Leadite, and special care was exercised during the construction work to assist the contractor as far as possible in obtaining good joints. The laborers were without experience in handling this material, and had some difficulty at first in heating the Leadite to the proper consistency, but after a little they became fairly proficient. Some of the joints were tested during the progress of the work, and the results were for the most part satisfactory. If the writer remembers correctly, it was necessary to cut out a few joints and repour them, owing to the cooling of the Leadite before the joints were sufficiently filled. As far as we have been able to ascertain, this pipe line has caused no particular trouble, and there is no indication at the present time that the Leadite joints are in anything but satisfactory condition.

" In 1912, under a contract with the Milford Water Company, Milford, Mass., for the Purchase Street pipe line, the contractor also chose to use Leadite for the pipe joints. As in the previous case, the laborers experienced considerable difficulty in handling the Leadite, especially in getting the material hot enough to be of the right consistency when the ladle reached the pipe joint. Several hundred feet of 8-in. pipe were laid with this material, and upon test it was found that a large percentage of the joints

leaked drops of water, while some of the joints actually leaked streams of water. The leaks were observed for a week's time, and it was found that the quantity of leakage gradually diminished in nearly all of the joints, so that the majority of the joints at the end of the week were apparently satisfactory. Some of the jointing material was cut out and the joints repoured, where the worst leakage occurred. By this time the contractor had spent so much time and care, and there still seemed to be so much uncertainty as to the action of the material, that he gave up using Leadite and went back to lead joints as being much more satisfactory. Whether or not the Leadite purchased in this particular case was of inferior quality to that used at Concord, we are unable to state, but in spite of great care the results were not nearly as satisfactory, and were, in fact, very disappointing.

"In private work we know of two cases where water-works superintendents are using Leadite under their personal supervision, with men trained in its use, and are obtaining satisfactory results, with a material saving in cost of jointing material.

"In view of the above experience, and after making certain tests and observations, we have omitted the use of Leadite in all specifications for municipalities, on the ground that it is an uncertain material in inexperienced hands, and where contracts are liable to be awarded to inexperienced or unreliable contractors, it seems to us unwise to allow the use of this material.

"Our experience has been that under such conditions the contractor charges the same price for Leadite as for lead, so that there is no saving to the municipality in allowing the use of Leadite, and there is hazard in the uncertainty as to whether or not the joints will be watertight. If the joints are not watertight it is a difficult matter to remedy the trouble, and an exceedingly difficult matter to persuade a contractor to cut out and repour the joints in several hundred feet of pipe line, to remedy the leakage.

"We are confident that in experienced hands, and under favorable conditions, Leadite can be used satisfactorily and with a material saving in cost, but under the conditions above mentioned we believe that it is neither advisable nor economical."

Mr. Henry L. Lyons, of Buffalo, writes that he used Leadite in about seven hundred feet of 6-in. pipe joints in 1905. This has been watched since, and has remained perfectly tight, a leak never having occurred, although Leadite has not come into general use in the Buffalo system.

Mr. John Palmer, general contractor, has used Leadite in one or two instances in Massachusetts towns, but is not satisfied with

the results, and has abandoned its use. The difficulty he experienced was in satisfying the authorities that the joints which showed seepage at the start would become tight and be satisfactory.

In 1911, the Hanscom Construction Company, of Boston, made a contract to build a complete water plant for the Barnstable Water Company at Hyannis, Mass. The contractors requested the privilege of using Leadite in the 16-in. supply line running two and one-half miles from the standpipe to the village of Hyannis, agreeing to keep open the joints until it was determined what the result would be, and removing such joints as proved defective. The consent was given, and the program was carried out. The writer, as engineer for this work, gave close attention to the method of melting and pouring Leadite and watched the joints closely after water had been turned on, which it was impossible to do for some weeks after the line had been laid. Water was then pumped to the top of the standpipe hill by a small pump connected into a blow-off, and the pipe was kept full intermittently for the next three months; during the period of the construction of the standpipe foundation, and the erection of the tank, the pressure varying from zero to 40 lb.

The first results were disappointing. We had been informed by the Leadite Company that the joints would leak for a few days, possibly a week, but the week came to an end and there was no sign of reduction. We waited rather impatiently another week, at the end of which time the joints were still flowing rather freely; in many places small spurts were noted. We then called for the Leadite Company to inspect the work and tell us what to do. They looked over the joints and advised us to let them set for a time longer. We had been continuing the use of Leadite in laying mains in other parts of the town where it was not possible to keep joints exposed. At the expiration of the third week, as the joints still leaked, it was decided unwise to continue, and we ordered the use of all Leadite stopped at once, and all further joints in the system made with lead, which was done. The leaks showed a marked reduction at about the end of the fourth week, so much so that they were eventually filled in, although they were far from tight, and even puddled the trenches to a slight extent. While no exact record of time was kept, it was probably about six or eight

weeks before we were able to dig up joints and find tightness, but the interesting part of this was that it was real tightness; the joints were dry. We could not find so much as a drop of leakage anywhere along the pipe line, and perfect tightness has continued since.

A few months later, the company received a contract for laying about twelve miles of cast-iron water mains from 4 in. to 16 in. in size in the town of Norton, Mass., and decided to use Leadite for the whole system.

In the case of the Barnstable Water Works the material laid through was largely dry sand; that in the second plant was hard and stony ground, to a great extent in water. I only need to comment on this to say that this plant has now been in operation with pressures varying from 60 to 150 lb. for about four years, and is giving extremely satisfactory results.

Following this, three years ago, the Hanscom Company used Leadite in the complete system for Greenville, Me.; and two years ago in Mattapoisett, Mass. Last year it was used exclusively in Groveland, Mass., and Haverhill, N. H. The total of these plants is approximately seventy miles, with the usual range in size of mains for plants of this kind. The results in every instance have been eminently satisfactory to the contractors and to the owners of the plants.

The Reading Contracting Company have had an experience with Leadite practically identical with that of the Hanscom Construction Company, having used Leadite for a period extending over ten years, and covering thirty miles of pipe lines. No sign of deterioration has appeared in any of their work, and extreme tightness has been obtained in practically all cases.

The principal advantages of Leadite are, in cost of joint material, reduced cost of bell holes, no calking, quick removal, extreme tightness; to say nothing of saving in handling a lighter material.

The disadvantages that we have met with are, the exactness required in melting and pouring joints, only experienced and trained men being suitable for this work.

We have found one test under which Leadite is very apt to fail, where lead joints will hold. That is where pipe is laid around sharp curves, so that one side of the joint is very thin. We have

had a few leaks in the joints of the systems referred to, and in practically every case it has proven to be from the latter cause.

I wish to refer again to the Groveland, Mass., pipe lines, where a particularly good opportunity occurred to get at the condition of the joints. Water for the town of Groveland is furnished by the city of Haverhill and is measured by passing through a Hersey detector meter. The action of the meter aroused suspicion, and the commissioners decided before accepting the plant to have an investigation by an engineer who had had no connection with the works. Mr. W. S. Johnson was chosen to make this test, and as Mr. Johnson has kindly consented to give the results of his investigation in person, the writer will not go into the details further.

It is desirable that some method of testing samples of Leadite be found, but as the composition is known only to the maker, it is rather a difficult matter to arrange. The writer extended a cordial invitation to Mr. McKay to furnish the Association with all details of the composition of Leadite, but Mr. McKay sends regrets.

The conclusions to be drawn from the foregoing experiences seem to the writer positive and to the effect that a very high standard of results can be obtained from Leadite under practically all conditions; that the greater degree of tightness is a very important matter, and worth much effort and expense to obtain; that the saving in cost of joint material and in labor of joint making gives still further cause for its extensive use; and last, that the real key to obtaining these benefits is thorough knowledge of proper methods of handling Leadite and the employment of skilled men.

[Discussion on this subject will be found on page 570.]

LEADITE FOR JOINTS IN CAST-IRON WATER PIPE.

BY W. C. HAWLEY.

[*Read September 7, 1915.*]

This paper was prepared at the request of the chairman of the Convention subcommittee on papers. If I am placed in the somewhat embarrassing position of boosting a proprietary article, my only excuse is the hope that the results of my experience as given in the paper may be helpful to some of the other members of the water-works fraternity.

It is about nine years since Leadite was called to my attention. The first experimental joints which we made with it did not prove satisfactory. Other trials gave better results. A service test was then made on a line of about seventy lengths of 6-in. pipe under light pressure. There was some seepage, but in an hour or two most of the joints had taken up, and in twenty-four hours all but three were tight, and those were easily repaired. Gradually we extended the use of Leadite under higher pressures and to larger pipe, and in two or three years practically abandoned the use of lead. The result of our experience has been most satisfactory. We have laid with it pipe ranging in size from 4 in. to 30 in. in diameter, and under pressures up to 210 lb. to the square inch.

While I know that Leadite is being used by many water-works men successfully, I also know that, after experimenting, a considerable number have given it up, and are still using lead. I have discussed this matter with a number of these gentlemen, and my opinion is, that the failure to get satisfactory results has come from improper manipulation of the material, generally due to a lack of understanding of how it should be used, but in a number of cases, I am sorry to say, due to the calkers or other workmen who feared that if Leadite were adopted they would lose their jobs.

Leadite comes in the form of a fine black powder. About one half of it is sulphur; the other half is, apparently, a finely

ground quartz with probably some lamp black to give it its color. Where melted and cast it becomes a black, hard, dense, vitreous mass. Any one who is familiar with the two substances, lead and sulphur, will realize at once that they have very different characteristics. Lead has a specific gravity of about 11.4; sulphur's specific gracity is about 2.0. In other words, a cubic foot of lead weighs in round numbers 710 lb., while a cubic foot of sulphur weighs 125 lb. Lead melts at about 612 degrees F.; sulphur at about 240 degrees F. Lead is ductile and soft; sulphur is brittle and hard. Lead will flow under a continued pressure of about 500 lb. per square inch; sulphur has a compressive strength of several thousand pounds per square inch. Lead expands one part in 63 012 for each increase of temperature of 1 degree F.; sulphur expands one part in 28 066; and cast iron expands one part in 162 000. It will thus be seen that lead expands about two and one-half times as much as cast iron, and sulphur nearly six times as much as cast iron. Incidentally, that is the reason why a lead joint should never be calked until the lead and iron have cooled to the original temperature of the pipe. Otherwise in cooling there is a shrinkage, and the lead shrinks more than the cast iron, and there will be more or less leakage. In making Leadite, this tendency of sulphur to excessive expansion and contraction as compared with cast iron has to be overcome by the material which is mixed with it. This has been accomplished successfully. Leadite has a strength in compression of about 7 000 lb. per square inch and weighs about 138 lb. per cubic foot.

In using Leadite, it is melted in a pot in the same manner that lead is melted, but since it melts at a much lower temperature, it is melted more easily. A small fire is required, but the Leadite should be stirred frequently from the minute it begins to melt until it is put into the ladle ready to pour the joint. Failure to do this has been the cause of many of the unsatisfactory results obtained. As the Leadite melts it froths and foams, and then, unless removed from the fire, it suddenly becomes thick and pasty. This indicates that the temperature has been raised to too high a point and is the signal to remove the kettle from the fire. Keep stirring. As the temperature then reduces, the

Leadite becomes like a thin, black oil with a peculiar gloss, free from froth and foam, and it is then ready to be poured into the joint. It does not require a man with any great amount of experience or technical ability to melt Leadite. After he has melted it a few times he can perhaps do it without heating it to the point where it becomes thick and pasty, but the safe rule is to carry it to that point.

The joint is yarned in the usual way, except that the yarn does not need to be driven quite so hard as it does for a lead joint which is to be calked. Any ordinary jointer will do, either a clay roll or a rubber band, but, on account of Leadite being so much lighter in weight than lead, in order to fill the top of the joint, the gate must be 8 in. to 10 in. high. This is made by forming a hollow clay cylinder with an internal diameter of about 1 in., and the Leadite is poured into the joint with moderate rapidity until the gate is full to the top. Pouring should be continued as the molten mass in the center of the gate shrinks and settles. The clay roll or jointer may be removed as soon as the joint is hard, but it is well to leave the gate until the joint has thoroughly cooled. When the gate is broken off, care should be taken that none of the Leadite in the top of the joint is cracked or broken. The gate can be thrown into the kettle and remelted.

When Leadite joints have been properly made, a large per cent. of them when tested should be found to be practically tight. There may be a small amount of seepage, and in a very few cases even an appreciable leakage indicated by water dropping from the joint or by a small spray. Practically all of these will take up tight within twenty-four hours, and such as do not become tight are readily made so by cutting out the portion which is leaking and re-running with Leadite, or, in case there is too much water, the portion of the joint which has been cut out can be filled with lead wool. If more than one or two per cent. of the joints made show leakage after twenty-four hours, it is an indication that the joints were not properly made. In a line of 12, 10, and 8 in. pipe, five miles long, laid under my supervision several years ago and tested in the open trench, there was but one leaking joint. This was repaired by cutting out part of the joint and re-running.

Lead has but one advantage over Leadite, namely, that, after

having been run, the joint can be calked. The calking adds materially to the expense of the joint, but there will be occasionally in a city street a joint immediately under some pipe, or otherwise inexcessible, where it may be advisable to use lead, so that in case of the joint being disturbed and leaking in the future it can be readily repaired by calking, whereas if it was Leadite it might be necessary to run a new joint or to cut out part of it, and replace with lead wool.

In practically all other respects Leadite has the advantage over lead. Leadite costs about 10 cents per pound, lead about 5 cents, but Leadite weighs about one fifth as much as lead and hence its cost per unit of volume is about two fifths that of lead. Leadite requires no calking, and this, as will be shown later, is a material saving, not only in the cost of the labor of calking, but in the digging of large bell holes, in addition to which is the saving in cost of inspection in order to insure well-calked joints. There is the further saving in the maintanenace of the ditch and bell hole during the time that the joint is being calked and inspected. This is an important item in bad ground, or in wet trenches.

In a case where there is limited room for calking, Leadite has marked advantage over lead. Some years ago I had a 30-in. pipe burst, the bell of which was very close to a concrete wall. It was barely possible to yarn the joint and then run the joint with Leadite. Had we been compelled to use lead it would have required hours of time to have cut out sufficient concrete to have permitted the calking of the joint. It was imperative that the pipe be repaired quickly, as a large community depended upon the line for its supply, and the use of Leadite saved us from a water famine.

I have found in laying pipe in city streets where we are not able to lay a long line and then test, but have to test maybe every two or three pipe lengths, we can put in a plug and run it with Leadite and test, then cut out the plug in a few minutes and back fill. I think it is even quicker than using testing plugs.

Leadite has another advantage over lead in the fact that it is so much lighter and hence more easily carried to the joint, especially in a deep ditch; also that a sufficient amount can be carried

in one ladle so that a large joint can be made at one pouring, whereas with lead two or three ladles must be used. When lead is at a temperature suitable for pouring, it oxidizes rapidly, and in spite of the utmost care the oxide and dross which gathers on the surface will sometimes be poured into the joint. There is no trouble of this kind with Leadite.

Since lead has practically no elasticity, any movement of pipe laid with lead joints or any continued shock or vibration to the pipe tends to loosen the lead in the joints or in many cases to squeeze it out altogether. Leadite, being elastic, is not so affected. I have known cases of side-hill slips moving a line of pipe laid with lead, and generally the first indication of trouble is a flood caused by the blowing out of a part or the whole of a joint. With Leadite joints, however, while the Leadite may be more or less crushed and may leak slightly, the joints do not blow out. This is a very important advantage, as side-hill slips generally cause damage to adjoining property, and one finds it difficult to convince those who have suffered damage or the Court that the slip caused the leak and not the leak the slip. The extent of the slip is likely to be much greater if there is material leakage from the joints after the pipe has been moved, and the liability for damage is thereby increased.

As stated above, a Leadite joint resists repeated shock. In one case a 20-in. cast-iron pipe, laid with lead, passed under a main line of a railroad on which the traffic was very heavy. For years it has been necessary to periodically uncover that pipe and recalk the joints. About ten years ago the lead in these joints was replaced with Leadite, and I am advised that there has not been a leak in these joints since.

Considering the brittle nature of Leadite, it is surprising what a Leadite joint will stand in the way of movement without serious damage. This has been illustrated in my own experience several times by side-hill slips, and in one case where it was necessary to lower a line of 8-in. pipe for a distance of nearly 300 ft., and to a maximum depth of about 2 ft. The pipe had been laid with Leadite, and it was not supposed that it could be lowered without damage to most of the joints, which would probably require them to be remade. It was decided, however, to try the experi-

ment, and the pipe was lowered, and to our surprise the joints remained tight.

Since Leadite melts at such a low temperature, there is no danger of an explosion, should it be necessary to run a wet joint. Where water is encountered a joint, can be made by leaving an opening at the bottom of the joint, out of which the water can run. An experienced man will then run the joint quickly, and in most cases will make a good job. If, however, the joint still leaks, it is an easy matter to cut the Leadite out where necessary and calk with lead wool. We find lead wool a very useful article in connection with Leadite joints where there is an excessive amount of water. Sometimes a kettle of melted Leadite will catch fire, and, of course, the fumes of the burning sulphur are extremely disagreeable. Usually the fire can be smothered by throwing on quickly some of the cold powdered Leadite. If this does not succeed, however, a pail of water will accomplish the desired end. Those who have seen water poured on to melted lead will be inclined to doubt this statement, but when we consider the low temperature at which the Leadite melts it is evident that there is no danger of an explosion.

Among Leadite's good qualities is the fact that it offers a high resistance to the flow of electricity, thereby reducing materially the danger of damage by electrolysis. A few years ago the United States Bureau of Standards made a test near Pittsburgh of two lines of pipe about a half a mile long, laid parallel in the same street. Both of these lines were crossed by a single-track trolley line and conveyed electricity from the trolley line back to a network of trolley lines in the city. One was a 16-in. cast-iron gas pipe laid with lead joints, the other was a 12-in. cast-iron water line laid with Leadite joints. I do not have the exact figures at hand, but the amount of current passing through the 12-in. water pipe was only a very small fraction of that which was passing through the 16-in. gas pipe.

Last, but not least, of Leadite's good qualities is the saving by its use compared with lead. Roughly speaking, on the ordinary sizes of pipe and under average conditions, this amounts to at least one half of the cost of lead joints. In my own experience, since Leadite was a new material and our pressures unusually

high, I have made Leadite joints with a depth of from 2⅛ to 2½-in., whereas with lead the joints would be made from 1¾ to 2 in. in depth. Used in this way we find, on the average, that the amount of Leadite and lead required for joints of different sizes is as shown in the following table.

TABLE.

SHOWING THE AVERAGE QUANTITIES OF LEADITE AND LEAD REQUIRED FOR JOINTS OF THE VARIOUS SIZES OF CAST-IRON PIPE.

Diameter of Pipe. Inches.	Leadite. Pounds.	Lead. Pounds.
4	2	7
6	3	10
8	4	13
10	5	17
12	6	21
14	7	25
16	8	29
20	10	37
24	12	45
30	15	57
36	18	69

The amount of Leadite required for a joint is equal to the internal radius of the pipe. I discovered a rather interesting thing in making up the table of weights for lead joints. We have been accustomed to figuring the amount of lead in a joint as three times the radius plus something, and the larger the pipe the more the *something* we add. I found when I had made the above table that for 4-in. pipe I had 7 lb. — twice the diameter less one pound; for 6-in. pipe, 10 lb., or twice the diameter less two pounds; and for all other sizes twice the diameter less three pounds.

On this basis, assuming the cost of Leadite at 10 cents per pound, and lead at 5 cents, lead costs from 1¾ to nearly twice as much as Leadite.

Labor costs vary according to the length of pipe laid and the difficulties encountered, but we have found on the average the cost of labor in making Leadite joints, including the melting of the material, the preparation and placing of the roll, yarning and pouring the joint, is one half of the corresponding cost of making lead joints, including the calking, this without making any allow-

ance for the extra cost of inspecting lead joints or for digging bell holes large enough for calking or maintaining bell holes while calking. As an example of what can be done, under good conditions, we have had three men yarn, melt, and pour 95 joints of 8-in. pipe in one day at a total cost for labor of $6.60, or a cost of 7 cents per joint. The total cost, including Leadite, was $49.00, or an average cost per foot of pipe of 4.3 cents. In this case the saving is well over 50 per cent. of the cost of making the same joints with lead.

The use of Leadite has passed the experimental stage. The excellent results obtained with it, the ease with which it is used, and especially its economy, have been demonstrated. The only question remaining is that of its durability. There seems, however, to be no reason to suppose that it will be less durable than lead. In fact, in these days of stray electric currents, it is likely to prove more durable. It would seem to be a material especially well suited for the small water works where it is difficult to secure the services of a calker. Any intelligent laborer can use it with a little instruction and experience. On most work the elimination of the calker — that bane of existence to the superintendent and engineer — would be worth while if it was the only advantage to be obtained. However, with all its other advantages it would seem, in these days of efficiency and economy, that it is at least worth a careful trial.

DISCUSSION.

Mr. J. M. Diven.* Mr. Hawley has given us some information which is entirely contrary to the generally accepted idea concerning Leadite, that is, as to its elasticity. We have generally thought that Leadite was brittle and rigid. The author has, by that statement, headed off some questions the speaker was going to ask; but the greatly differing experiences we hear leave us all in doubt as to whether to adopt Leadite or not. We hear one man tell of satisfactory results; another totally condemns it, both giving personal experiences to back their judgment. One drawback seems to be the proper temperature for melting, and

* Superintendent Water Works, Troy, N. Y.

it would help the novice if the makers of Leadite would devise a melting pot with thermostat or some other device that would give us the proper temperature for melting.

The speaker is still in doubt about the wet joints. Mr. Hawley explained that the jointer is left open at the bottom for the water to run out. It seems as though the Leadite would follow the water; we would like to have a little more explanation of that point from Mr. Hawley. He has also explained the electrolysis feature, which is certainly very interesting.

Another thing which is troubling the speaker a little is why these joints tighten up after two or three weeks, or perhaps some months. It would almost seem as if the joints would be as tight in twenty-four hours as they would be after several weeks.

One other point is the possible injurious action of sulphur on iron. We know that sulphur acts injuriously on iron pipes. The speaker has had to lay water pipes in soil that is impregnated with sulphur from phosphate works, and they did not last long. Is there any possibility of the sulphur in Leadite joints having eventually an injurious action on the pipes?

Mr. Frank L. Fuller.* Mr. President, I suppose that it has always been considered that a lead joint was as flexible a joint as we could have. Mr. Hawley seems to speak of the Leadite joint as being more flexible than a lead joint. I would like to ask him if he means that.

Mr. D. A. McCrudden.† I think that the example Mr. Hawley gave, of dropping an 8-in. pipe two feet in a distance of 300, does not show such an awful lot of flexibility. If he had tried to drop a 38- or 48-in. pipe three feet in about 300 it would have made a lot of difference. I do not think he could get the Leadite back.

Mr. George H. Finneran.‡ I should like to ask Mr. Hawley if he has found that Leadite is subject to deterioration with age and exposure to the weather and to water. Also, if, when Leadite reaches that thick stage that he speaks of, wherein it is supposed

---

* Civil Engineer, Boston, Mass.

† Purveyor, Bureau of Water, Philadelphia, Pa.

‡ Assistant Superintendent, Water Service, Boston, Mass.

to be too hot, he removes the heat entirely or allows just a little heat to play upon the pot?

MR. HAWLEY. Answering the last question, we simply take the fire away from the kettle or the kettle away from the fire and keep stirring it. After a while it thins down to the proper consistency for pouring. As to its deterioration with age, we have found no indication yet of any deterioration.

MR. FINNERAN. About six years ago we tried Leadite in Boston and laid about 300 ft. of 8-in. pipe with success. It is in the ground to-day and there is no indication of leakage. We then endeavored to find out how large a joint could be made up with Leadite. We tried several times unsuccessfully to join 30-in. and 20-in. caps to the ends of a 30 by 20 reducer. Each time the joints failed to hold the ordinary low-service pressure of 50 lbs. We finally gave it up. We still have on hand some of the Leadite used at that time and recently have used it with good results. I am wondering whether it would retain its effectiveness indefinitely. Some such compositions deteriorate with age and change of conditions. Have you had any experience in that line?

MR. HAWLEY. No, sir. So far as I know the element sulphur, I think that we have no reason to expect it to change merely from age. Mr. Diven's experience with cinders, of course, is an entirely different proposition. When the coal burned, the sulphur which it contained was oxidized to sulphur dioxide, some of which remained in the cinders. This was leached out by water and formed sulphuric acid. Pure sulphur does not attack the iron in the pipes, though it seems to take hold of the inside of the bell much better than lead. Most of us have used sulphur for setting holding bolts or engine beds without expecting it to attack the iron in such cases.

As to the difficulties of melting, I expected some trouble from our men who had been using lead, so we chose a boy about eighteen or nineteen years old, — a water boy, — and after our foreman had experimented enough with Leadite to learn how to use it, he taught that boy how to use it. He is the one who has melted the Leadite and run the joints for several years, and we have another boy that is doing it. We have found no difficulty with it so long

as they do it carefully, bring it up to the temperature where it begins to thicken and then let it cool down. In regard to the large-sized joints Mr. Finneran speaks about, we have had no difficulty except in the case of some valves or sleeves where the joint was large, that is, thick. When we get up to an inch or an inch and an eighth joint we have some trouble. Yet we have run some of those large joints.

MR. DIVEN. It would be interesting if one of the writers would explain whether the Leadite joints are melted or cut out with a chisel, and about the disposal of water in the joints when pipes are laid in wet trenches.

MR. HAWLEY. As far as my experience goes in cutting out joints, it is the practice to dovetail back both ways with a chisel. Leadite cuts out a good deal like hard putty around a window pane. Of course, while Leadite itself is hard, it is elastic. Glass is hard, steel is hard, but they are elastic. You can bend a pane of glass or a bar of steel and they will spring back to their original position. Lead, on the other hand, is not elastic. Bend a piece of lead pipe and it does not spring back to its original shape; strike it with a hammer, and it makes a dent; the hammer does not rebound. Referring to the running of wet joints, I have had no personal experience, but in talking with my foreman the other day he told me that when he has trouble with water he leaves a small opening at the bottom of the joint and then pours the joint quickly. Generally the joint is tight; if not, that portion which leaks is cut out, being dovetailed back on each side, and it is calked with lead wool.

MR. GEORGE F. MERRILL. I would like to know how a Leadite joint compares in conducting electricity with a lead joint — how it affects it.

MR. HAWLEY. Sulphur has a very high resistance to the flow of electricity. We tested out Leadite by trying to pass a current of electricity through it. It practically stopped the electric lighting current. We have, in a number of cases where we have had a break, replaced the pipe with a sleeve, using Leadite. The Bureau of Standards, when their men were there, tested some of

* Superintendent Water Works, Greenfield, Mass.

those and found the resistance to the flow of electricity very much higher than where lead was used.

MR. DIVEN. Would not the high resistance be an objection, because when the electric current reached the joint it would jump to the next length of pipe, and the point of leaving the pipe is where the injury is done.

MR. HAWLEY. It is true that when the electric current reaches the joint it will have to jump to the next length of pipe, but the high resistance of the Leadite joints increases the total resistance of the line to such an extent that the amount of electricity returning to the generator is very much less than where lead is used. Since the damage by electrolysis is in direct proportion to the amount of current, and since Leadite by increasing the resistance materially reduces the amount of current, it reduces the damage by electrolysis.

In the city of Pittsburg they have undertaken to overcome their electrolysis troubles not by increasing the resistance, but by putting bonds around the joints. They have thus decreased the resistance tremendously. The result is that they are returning an astonishing amount of electricity by way of their pipe lines, and the trouble is that their electrolysis troubles later are going to be general instead of local. In these lines I spoke of, the 12-in. water line and 1[illegible] gas line, if I remember rightly, the amount of electricity through [illegible]e water line was one one-hundred and fiftieth of that flowing through the gas line. Now that amount is going to do much less damage than the large amount of current going through the gas pipe.

MR. A. E. MARTIN.* In Springfield, Mass., we have had a little experience with Leadite during the last year. We have laid perhaps half a dozen miles of 8-in. pipe this year with Leadite joints and have had very good results. But one or two experiences on a little larger scale may be worth while to present at this time. Of course, in commencing its use we asked the Leadite men for help, and one of their representatives came to us to show us how to melt it. We had to make an 8-in. connection with a 30-in. line, using the tapping machine and split sleeve, and asked

* Superintendent Water Works, Springfield, Mass.

him if he would advise the use of Leadite in making the joint. He assented and poured the joint with Leadite, and when the water first came while tapping the pipe it leaked very fast. We were afraid of it, but he said, " Keep on." We made the cut and when we got it made the leak virtually stopped. We left it open twenty-four hours after making the connection with the line and it was perfectly tight at the end of that time. But a peculiar thing about the job was that we had not used Leadite in laying the 8-in. pipe connection to it, and in driving the lead joints of the connection near this tap, we loosened the sleeve joint and got lots of water again. He still said, " Let it rest and I will guarantee it will be tight in twenty-four hours," — and it was. The joint still " rests," and we have had no trouble with it. We have tapped the 30-in. pipe a number of times during the last year, using Leadite for the joints, and have had no trouble.

We have made one 8-in. tap off a 36-in. pipe for a hydrant connection, where we have a working pressure of 150 lb. The joint acted in much the same way and we were rather timid about it. The representative was not with us at that time. But within twenty-four hours the leaks had entirely ceased and everything has been all right so far. It was perhaps four months ago when we made this last test.

Another experience we had may be of interest. We have still some cement-lined iron water mains in Springfield, and among others a 24-in. supply line from the old Ludlow reservoir. We have had to tap that main in several places, and in the first tap we made, we had bad luck with the Leadite; we left the joint for twenty-four hours, but there was apparently no difference in the leak. The foreman did not want to take off the sleeve and run the joint again and I did not want to cut the pipe and put in a T, so I allowed him to experiment with it. He shut the water off, draining it below the outer joint, and then cut the Leadite out completely through the sleeve, right in the neck of the valve. Then he ran that part of the joint over again, and it came out perfectly tight — and we have no further trouble with it.

Mr. Lincoln Van Gilder * (*by letter*). Our twelve years'

* Engineer and Superintendent Water Department, Atlantic City, N. J.

experience with Leadite for pipe jointing, as noted in Mr. Symonds's paper, has been very satisfactory, and a recent experience has developed a new feature that may be of professional interest.

The new Hotel Traymore is equipped with high lift plunger elevators, the casings for which were driven for the most part through saturated sand with the casing heads and valve gear considerably below ground water level.

In finishing the pits the contractors were unable to stop the seepage, especially around the casings.

About half the required thickness of pit bottom was laid with concrete, and after hardening a thin layer of molten Leadite was poured all over it, the ground water being kept down by pumping until the Leadite was chilled. The pit was then filled to the required elevation with concrete.

Ten elevator pits were treated in the same way and every one is water tight.

In the same hotel it was necessary to tun two 4-in. discharge pipes through the side of a large concrete tank built for sea-water storage.

Rough holes were cut, the pipes run through and the space between pipes and concrete poured full of molten Leadite. These joints are dry.

All of the Leadite used on this work was handled by water department men, as the contractors had no knowledge of its properties or methods of application except by observation of the department's work on the adjacent street.

PROCEEDINGS.

HOTEL BRUNSWICK,
BOSTON, MASS., November 10, 1915.

Vice-President William F. Sullivan in the chair.
The following members and guests were present:

HONORARY MEMBERS.

E. C. Brooks, R. C. P. Coggeshall, Albert S. Glover, F. E. Hall, W. T. Sedgwick, and G. A. Stacy. — 6.

MEMBERS.

L. M. Bancroft, J. W. Blackmer, F. L. Cole, J. H. Cook, A. W. Dudley, E. D. Eldredge, G. F. Evans, S. F. Ferguson, F. L. Fuller, Patrick Gear, F. J. Gifford, H. J. Goodale, R. K. Hale, E. A. W. Hammatt, L. M. Hastings, D. A. Heffernan, A. C. Howes, Willard Kent, G. A. King, John Knickerbacker, H. V. Macksey, A. E. Martin, W. E. Maybury, John Mayo, H. A. Miller, William Naylor, F. L. Northrop, T. A. Pierce, W. H. Pitman, J. L. Rice, L. C. Robinson, H. F. Salmonde, G. A. Sampson, P. R. Sanders, C. M. Saville, A. L. Sawyer, J. E. Sheldon, C. W. Sherman, E. C. Sherman, H. H. Sinclair, J. T. Stevens, W. F. Sullivan, R. J. Thomas, J. A. Tilden, A. H. Tillson, D. N. Tower, W. J. Turnbull, W. H. Vaughn, R. S. Weston, F. B. Wilkins, F. I. Winslow, G. E. Winslow, L. C. Wright. — 53.

ASSOCIATES.

Harold L. Bond & Co., F. M. Bates; Builders Iron Foundry, A. B. Coulters, F. N. Connet, and D. K. Bartlett; A. M. Byers Co., H. F. Fiske; Central Foundry Co., W. H. Felet; Chapman Valve Mfg. Co., J. T. Mulgrew; Darling Pump and Mfg. Co., Ltd., H. A. Snyder; *Engineering Record*, I. S. Holbrook; Hayes Machinery Co., F. H. Hayes; Hersey Mfg. Co., James A. Tilden, Albert S. Glover, and J. Herman Smith; Ludlow Valve Mfg. Co., A. R. Taylor and G. A. Miller; H. Mueller Mfg. Co., G. A. Caldwell; National Meter Co., J. G. Lufkin and H. L. Weston; Neptune Meter Co., H. H. Kinsey; Pittsburgh Meter Co., J. W. Turner; Rensselaer Valve Co., F. S. Bates and C. L. Brown; A. P. Smith Mfg. Co., F. L. Northrop; Thomson Meter Co., E. M. Shedd; Union Water Meter Co., F. E. Hall and D. K. Otis; Water Works Equipment Co., W. H. Van Winkle; Henry R. Worthington, Samuel Harrison, and W. F. Bird. — 29.

GUESTS.

Hazen Pillsbury and Wm. F. Hunt, Lowell, Mass.; F. O. Eichelberger, Dayton, Ohio; Louis W. Thayer, Braintree, Mass.; J. A. Tilden, Jr., Boston, Mass.; E. J. Dunphy, Cambridge, Mass. — 6.

VICE-PRESIDENT SULLIVAN. It is with regret that I announce the death this week of a long-time member of this Association, a man who for over twenty-five years has attended these meetings. I refer to Mr. Eben R. Dyer, of Portland, Me., superintendent there so many years. I understand his funeral takes place about this hour to-day, and as a mark of respect I would ask all the members to rise and remain standing in silence.

The members stand in silence, as requested.

MR. R. C. P. COGGESHALL, of New Bedford. Mr. President, It is with a sudden shock that I heard this sad tidings. It seems as though death had been very busy in our ranks of late. Fully twenty-five years I have known Eben Dyer and known him to be a good citizen, a conscientious official, and a worthy member of this Association. Peace be to his memory.

The Secretary presented the following applications for membership, properly endorsed and recommended by the Executive Committee:

Active: Homer R Turner, Windsor, Conn., superintendent Water Department of the Windsor Fire District; Hazen G. Pillsbury, Lowell, Mass., service clerk, Lowell Water Department; Homer F. Cox, Scranton, Pa., railroad and general engineering work; Horace Belden, Simsbury, Conn., president and manager Simsbury Water Co.; Thomas Grieve, Perth Amboy, N. J.; M. Z. Bair, Columbus, Ohio, assistant engineer Ohio State Board of Health; J. Arthur Durst, Philadelphia, Pa., water-works construction; Frank E. Hale, Brooklyn, N. Y., director of laboratories, Department Water Supply, Gas and Electricity, New York City; Charles H. Fischer, Jersey City, N. J., examining water-works systems from a fire protection standpoint; Ernest B. Bain, superintendent water works, Raleigh, N. C.; C. L. Kirk, Indianapolis, Ind., president Indianapolis Water Co.; John Gaut, Washington, D. C., water filtration; Dow R. Gwinn, Terre Haute, Ind., president and manager water works; F. O. Eichelberger, city engineer, Dayton, Ohio. — 14.

Associate: Lock Joint Pipe Co., New York City, manufacturers of reinforced concrete pipe. — 1.

On motion, duly seconded, the Secretary was directed to cast the ballot of the Association in favor of the applicants, and he having done so they were declared duly elected members of the Association.

MR. CHARLES W. SHERMAN. Mr. President, Mr. Frederic P. Stearns was unfortunately called out of Boston last evening, and asked me to present in his behalf the report of the Committee on the Dexter Brackett Memorial, together with a memoir on Dexter Brackett's life.

The report and memoir were read by Mr. Sherman, and on his motion it was voted that they be accepted and printed in the JOURNAL and a copy sent to Mrs. Brackett, the adoption of the motion being expressed by a rising vote.

MR. SHERMAN. Mr. President, the committee was charged with two duties: first, to prepare the memorial which I have just read; and, second, to consider a proposition offered at the convention in New York last September as to a memorial in the Association to Mr. Brackett's memory. The report on the second subject is as follows:

NOVEMBER 9, 1915.

TO THE NEW ENGLAND WATER WORKS ASSOCIATION:

Gentlemen, — The committee appointed by your President, under a resolution adopted at the last annual convention of the Association, to consider the question of a suitable form of memorial to perpetuate the memory of Past President Dexter Brackett, has given the matter careful consideration.

The committee believes that there should be a memorial and that the most appropriate form is a bronze medal, to be awarded each year as a prize for a meritorious paper. It seems desirable, if the Association adopts the views of the committee, that much care should be taken in formulating the rules for the award of the medal, and that a committee be appointed for this purpose.

The committee is of the opinion that an artistic bronze medal is preferable to one made of gold, and quotes the reasons given in another case by our fellow-member, Mr. Desmond FitzGerald, that "the prize should be valued not for its intrinsic worth but solely as a testimonial that the holder of it has contributed something which his fellow-members consider of great value . . .; also that the evidence of having received such an award will be more available and less likely to be deposited where it can seldom be seen if the medal is of bronze rather than of a precious metal."

Inquiry of Mr. FitzGerald, who has had experience in these matters, elicited the information that a satisfactory result could not be secured much short of

$1,000. The expenditure would be required mainly for the artistic design and the cutting of the dies, as the cost of the medals themselves would be small.

The committee thought it undesirable to make a general request for subscriptions from members of the Association, and has therefore sent a request to about forty persons, nearly all members of the Association intimately acquainted with Mr. Brackett, asking them to subscribe to a guarantee fund. Although the request was made only a few days ago and the returns have not all been received, the response has been a very generous one, and it is evident that a sufficient sum will be guaranteed.

Although the committee has ascertained that a comparatively few members of the Association are willing to guarantee the success of the fund, it believes that other friends of Mr. Brackett who are members of the Association should be given an opportunity to make a small subscription if they so desire, and the committee therefore recommends that if its views are adopted a notice be sent to all members, not as an appeal or even a request for subscriptions, but rather to give an opportunity for those who desire to subscribe to the fund.

My associates on the committee, Messrs. Alfred D. Flinn and Allen Hazen, have expressed views which accord with the statements in this report, but to avoid delay it has not been submitted to them in its final form.

For the committee,

FREDERIC P. STEARNS.

MR. SHERMAN. I will say, Mr. President, that in order to be sure that this subject received more adequate consideration than was usually possible at a general meeting of the Association, the Executive Committee at its session this morning took it under consideration and has prepared the following vote for submission to the meeting, of which it recommends the adoption.

Voted, That the report of the Committee on the Brackett Memorial be adopted and they be requested to formulate a notice to be sent to the membership so as to give an opportunity for all to subscribe, and that the President appoint a committee to receive subscriptions, procure a medal of suitable design, and to formulate rules for the annual award of such medal.

On motion duly made and seconded it was voted that the report be accepted and its recommendations adopted.

It was further voted that the motion submitted to the meeting by the Executive Committee be adopted.

VICE-PRESIDENT SULLIVAN. The next business is the report of the Committee on Engineering Coöperation.

SECRETARY KENT. Mr. Davis of the committee writes as follows.

[The letter from Mr. Carleton E. Davis is read by the Secretary, and on motion duly made it is voted that the report be accepted and the recommendation adopted.]

SECRETARY KENT. I have here a communication from the Committee of Manufacturers on Standardization of Fittings of Valves.

The communication from the Committee of Manufacturers on Standardization of Fittings of Valves, by A. M. Howser, was read by the Secretary.

MR. BROOKS. I move that a committee be appointed on valves, to confer with the committees from the other societies, to arrive at a uniform standard, if possible, for water-works and other works.

VICE-PRESIDENT SULLIVAN. Of how many, Mr. Brooks?

MR. BROOKS. I will leave that with the Chair.

The motion, being duly seconded, is adopted.

MR. COGGESHALL. Mr. President, I have a little matter that I want to bring before this Association. A few days ago a committee of the Master Plumbers Association in New Bedford appeared before the New Bedford Water Board, not in a complaining mood, but in an attitude asking advice. It seems that we have had two very disastrous domestic hot water boiler explosions in New Bedford. While they recognize that the function of the Water Department was simply to deliver the water into the house and that it was not responsible after that, they did want to know if the Water Board could give them any advice as to procedure in the matter of installation to prevent the occurrence of such troubles. We all know the troubles that have come by the vacuum that is created by the shutting off of mains. But this is a real boiler explosion. We none of us think it is possible for that thing to happen as long as there is a direct connection maintained between the boiler and the city main, because we believe the pressure would adjust itself. Nevertheless, this has occurred, and they have asked for advice on that point. Some of them have already been installing safety valves. Of course, some of our valve men tell us that they have got perfect safety valves, but

some of us think the perfect safety valve is going to come about the time a man dies and then it will be of no use. I told them I would bring that matter up before the Association, and that perhaps some members could later on help solve that problem. I am going to suggest that that be assigned as a topic for discussion at the next meeting, or whenever the committee sees fit to put it on the program. I make that as a motion.

The motion, being duly seconded, is adopted.

There being no further business to come before the meeting, the first paper of the day was read by Mr. Arthur W. Dudley, consulting engineer, Manchester, N. H., the subject of the paper being "Experience with Wood Water Pipe in New Hampshire." Mr. Dudley's paper was illustrated by lantern slides. It was discussed by the following named gentlemen: Messrs. Richard A. Hale, of Lawrence, Mass.; Mr. F. I. Winslow, of Boston; Mr. Gorham Dana, of Boston; Prof. Dwight Porter, of Boston; Mr. Frank L. Fuller, of Boston.

Mr. Edward C. Sherman, consulting engineer, Boston, Mass., contributed the next paper, on "The Wakefield Water Sterilization Plant," the paper being illustrated by lantern slides. Messrs. Frank L. Fuller and Robert S. Weston, of Boston, and Caleb M. Saville, of Hartford, Conn., discussed the paper, and a written contribution to the discussion from Mr. J. A. Kienle, of New York, was presented.

Prof. William T. Sedgwick, Professor of Biology and Public Health at the Massachusetts Institute of Technology, delivered an address on "Water Supply Sanitation in the Nineteenth Century and in the Twentieth," the address being commented upon by Mr. Robert S. Weston.

Following Professor Sedgwick's address, Vice-President Charles W. Sherman read a paper on "Grouting or Cushioning Standpipe Bases," the paper being discussed by Mr. Frank L. Fuller, of Boston. This completed the program of the meeting.

MR. BATES.* Mr. President, as an associate member I would like to have the privilege of the floor for a minute. During the first part of the afternoon session a paper in regard

* Of the Rensellaer Valve Co.

to valve manufacture came up, and a communication was read from Mr. Howser saying that it had been referred to the valve manufacturers. Since the reading of the paper the valve manufacturers here have gone over this matter carefully and find that that set of specifications has never been before the valve manufacturers, and we are completely ignorant of it. Such being the case, we would like to have Mr. Brooks reconsider his motion and have the same laid on the table.

MR. BROOKS. I think, Mr. President, that if it is a fact that that communication which was read at the meeting of the Executive Committee was not duly authorized, it would be rather unwise for us to take action on it. I would like an expression of opinion on that.

VICE-PRESIDENT SULLIVAN. As I understand the motion made by Mr. Brooks, it was that the President should appoint a committee to get up specifications for a standard valve.

MR. BROOKS. Well, it was to confer with —

VICE-PRESIDENT SULLIVAN. With the other associations.

MR. BROOKS. With the other committee. Now, have we any evidence except this, that a conference is desired?

VICE-PRESIDENT SULLIVAN. What is your pleasure, gentlemen?

MR. GEORGE A. STACY, of Marlboro. Mr. President, it seems to me that we were laboring under a misunderstanding. As I understood it, this virtually comes from the valve manufacturers. That is, they had been conferred with and had consented to this being presented to this meeting at that time. If that is erroneous, certainly we ought to drop the subject.

VICE-PRESIDENT SULLIVAN. Mr. Bates, how many valve manufacturers have been in meeting this afternoon?

MR. BATES. The Chapman, Ludlow, Rensellaer, and Eddy valve companies were represented.

VICE-PRESIDENT SULLIVAN. They know nothing about this?

MR. BATES. No, sir. This communication came from one concern only.

MR. BROOKS. I will make a motion, Mr. President, that the motion to appoint the committee be reconsidered.

The motion being duly seconded is adopted.

Mr. Brooks. I would move now that the matter be laid on the table.

The motion being duly seconded is adopted.

On motion of Mr. Charles W. Sherman, the meeting adjourned.

December Meeting.

Hotel Brunswick,
Boston, December 8, 1915.

Vice-President Sullivan in the chair.

The following named members and guests were in attendance:

Honorary Members.

E. C. Brooks, R. C. P. Coggeshall, Albert S. Glover, F. E. Hall, G. A. Stacy, and R. J. Thomas. — 6.

Members.

C. L. Baker, L. M. Bancroft, F. A. Barbour, A. E. Blackmer, J. W. Blackmer, Bertram Brewer, G. A. Carpenter, W. R. Conard, B. I. Cook, C. E. Davis, A. O. Doane, John Doyle, H. P. Eddy, W. R. Edwards, E. D. Eldredge, F. L. Fuller, Patrick Gear, H. T. Gidley, F. J. Gifford, T. C. Gleason, H. J. Goodale, F. W. Gow, F. H. Gunther, R. K. Hale, C. R. Harris, T. G. Hazard, Jr., D. A. Heffernan, J. L. Howard, G. A. Johnson, E. W. Kent, Willard Kent, S. E. Killam, G. A. Kent, John Knickerbacker, Morris Knowles, H. O. Lacount, F. A. McInnes, H. V. Macksey, A. E. Martin, W. E. Maybury, John Mayo, J. H. Mendell, F. E. Merrill, G. F. Merrill, H. A. Miller, F. L. Northrop, H. E. Perry, Dwight Porter, H. G. Pillsbury, J. H. Remick, L. C. Robinson, G. A. Sampson, P. R. Sanders, C. M. Saville, A. L. Sawyer, W. P. Schwabe, J. E. Sheldon, C. W. Sherman, E. C. Sherman, H. H. Sinclair, G. Z. Smith, Sidney Smith, W. F. Sullivan, H. A. Symonds, R. D. Thorpe, E. J. Titcomb, D. N. Tower, W. J. Turnbull, C. H. Tuttle, R. S. Weston, F. B. Wilkins, F. I. Winslow, G. E. Winslow, I. S. Wood. — 74.

Associates.

Harold L. Bond & Co., H. L. Bond and G. S. Hedge; Builders Iron Foundry, A. B. Coulters; A. M. Byers Co., H. F. Fiske; Darling Pump and Mfg. Co., Ltd., H. A. Snyder; *Engineering News*, Harry Barker; Hersey Mfg. Co., Albert S. Glover and J. Herman Smith; Lead Lined Iron Pipe Co., T. E. Dwyer; Ludlow Valve Mfg. Co., A. R. Taylor and G. A. Miller; National Meter Co., J. G. Lufkin and H. L. Weston; National Water Main Cleaning Co., B. B. Hodgman; Neptune Meter Co., H. H. Kinsey; Pittsburgh Meter

Co., J. W. Turner; Rensselaer Valve Co., F. S. Bates, C. L. Brown; A. P. Smith Mfg. Co., F. L. Northrop; Standard Cast Iron Pipe & Foundry Co., Wm. F. Woodburn; Thomson Meter Co., E. M. Shedd; Union Water Meter Co., F. E. Hall and E. K. Otis; Water Works Equipment Co., W. H. Van Winkle; R. D. Wood & Co., H. M. Simons; Henry R. Worthington, Samuel Harrison, and W. F. Bird. — 28.

GUESTS.

James J. Scully, president Water Board, Cambridge, Mass.; L. M. McKenney, inspector, Portland, Me.; Frank S. Hamlin, commissioner, Haverhill, Mass.; W. H. Lem, commissioner, Abington, Mass.; W. A. Bradford, Quincy, Mass.; W. P. Melley, inspector, Milton, Mass.; C. A. Bingham, general manager, Norwood, Mass.; R. A. Callum, superintendent, Cherry Valley, Mass.; J. M. Stevenson; George W. Simons, assistant professor Massachusetts Institute of Technology, Boston, Mass.; T. C. Atwood, New Haven, Conn.; H. W. Dotten, Waterford, N. Y.; E. S. Locke, Lexington, Mass.; H. W. Coombs, Boston, Mass., and Col. S. A. Carter, chairman Water Board, Concord, N. H. — 15.

The Secretary presented applications for membership from the following named, properly endorsed and recommended by the Executive Committee:

William E. Whittaker, Somerville, Mass., civil engineer, etc., Metropolitan Water Works; William N. Davenport, Newton, Mass., secretary Metropolitan Water and Sewerage Board; Henry T. Sawyer, Brighton, Mass., inspector and foreman for the Metropolitan Water Works since August, 1897; Charles A. Farnham, Collinsville, Conn., superintendent Collinsville Water Co. since 1904; Thomas C. Atwood, New Haven, Conn., now consulting engineer, previously connected with the Metropolitan Water Works, U. S. Engineers' Office in Boston, Philadelphia and Pittsburgh Filtration Works, and the New York Water Supply; W. Dayton Frederick, Bridgeton, N. J., commissioner of public works; J. Frederick Jackson, New Haven, Conn., general engineering practice, water and sewerage works; F. Spencer Goodwin, Hartford, Conn., water commissioner; John Franklin, Andover, Mass., private engineering practice, formerly city engineer of Hudson, N. Y.

On motion of Mr. Sherman the Secretary was directed to cast a ballot in favor of the applicants named, and, he having done so, they were declared duly elected members of the Association.

Vice-President Sullivan then called for any other business.

MR. HENRY A. SYMONDS. There is one matter, Mr. President, which I want to mention to-day, for the conditions are such at this meeting that I think something should be done to start the matter off. I refer to the question of having some sort of a representation of this organization before the legislative committees. Before another meeting of the Association the legislature of Massachusetts will have convened, and I think the legislatures in some of the other New England states are coming together at about the same time. It has seemed to me, and to others who have been called in consultation in a personal way in connection with matters that are brought before the legislature of Massachusetts, that this organization should be represented, and should be better informed through some such representation of what is being done and what is being proposed along the lines of matters having to do with the question of water supply. I invited the Senate chairman of the last year's water supply committee to be with us here to-day, and hoped that he might give to the Association a few of the points that he has given to me as to the difficulties which the water supply committees encounter in trying to pass upon matters which are presented for their consideration. The committee is usually composed very largely, if not entirely, of men who have had no connection whatever with water supplies, and the men who come before the committee are very largely men who have private interests. It is very seldom that the general community is represented by any one.

There is no question but that this organization stands in a position more fully representing the best interests of the people of New England than any other body of men, and it seems to me that there is something wrong when laws vitally affecting questions of water supply in New England and in the country at large are being put through the legislature without even one in a hundred, I might say, of the members of this Association having knowledge that such measures are being proposed.

In speaking of this matter to-day, I have not been able to formulate any definite plan, or, at least, anything more definite than to suggest that a committee be appointed to look into this matter. I appreciate the fact that many obstacles will occur to you at once in considering the question of the possibility of supervising

or looking into the proposed measures of this nature throughout the New England states, but it seems to me that there may be a way of getting around the obstacles in a manner which will be a benefit to the Association and to the communities.

During the last session of the legislature, several measures were proposed, and through the mere circumstance that some one interested in water matters generally happened to notice them upon the calendar, and sent out a few letters to friends and others who would be interested and thereby secured a fair representation, it happened that some very unfortunate measures were prevented from becoming laws, — measures which were entirely local, in some cases, but, nevertheless, which would have done considerable harm to the general question of water supply. We have some laws on our statute books at the present time that I am sure never would have been favored by this Association as a whole.

Now, to bring this matter to a head, I will make a motion that a committee of five be appointed by the Chair to look into this matter and to propose at some future meeting some method of taking care of it.

The motion was seconded by Mr. Robert J. Thomas.

Mr. Walter P. Schwabe. I would suggest that one member be appointed from each New England state, so that the number will be six instead of five.

Mr. Charles W. Sherman. I object to the amendment suggested. It seems to me we will do far better if we concentrate on one state in the first place and find out whether it is desirable for the Association to go into the matter at all. Then, if we find it is desirable in Massachusetts, it may be equally desirable in some other states; and if it is found not to be desirable in Massachusetts, it would be better to keep out of it entirely. I suggest that the committee consist of five members from Massachusetts, and that they take up the matter as affecting Massachusetts first, and afterwards, if it is found to be desirable, it can be extended to other states.

Mr. George A. King. Mr. Symond's motion is that the committee should report back to the Association some method for taking action. I would suggest that the committee be in-

structed to consider merely the advisability of the Association taking any action.

VICE-PRESIDENT SULLIVAN. Will the maker of the motion please state it again?

MR. SYMONDS. I would like to withdraw the motion as I made it originally, and I would move that a committee of six be appointed to look into and report back to the Association the advisability of its being represented before the legislatures of New England in connection with matters affecting the question of water supply.

MR. JOSIAH S. MAXCY. As I understand the motion, it seems to me that it is not in quite the shape that it ought to be in order to handle this matter well. It embodies the idea of having some one whose duty it will be to represent the Association before the various legislatures of New England. Now, if we are to have a man who is able to represent the Association properly, and who is willing to give the time that is necessary, it means that we must pay him. There are too many attempts being made of late to utilize ability for nothing, and when you try to do that you generally buy a gold brick. Now, it is all right to have a legislative committee which can keep in touch with the various matters of interest to us which come before the legislature, and when they thought any particular legislation should be opposed they could come back to the Association, or to the directors, and get money and hire a man to do a good job. That would be all right; otherwise, merely saying that we shall be represented may mean that we will not be represented at all, or possibly will be misrepresented.

Mr. Symonds' motion was rejected.

MR. H. P. EDDY. In spite of the apparent disinclination of the Association to pass this motion, I believe there is a general feeling among a great many that this is a matter of considerable importance and one that should receive the consideration of this Association in the proper way and at the proper time. It occurs to me that the wisest way to handle the matter is to refer it to our Executive Committee with power to report back — which it would have without special authority — to the Association what action it thinks the Association should take. Therefore I move you that this matter be referred to the Executive Committee.

Mr. Eddy's motion was adopted.

Caleb Mills Saville, chief engineer Hartford Water Works, then presented a paper, illustrated by stereopticon views, entitled, "Some Water-Works Experiences: Emergency Pumping Station; Testing Distribution Main; Old-Cast Iron Pipes; Double Check Valve Experiences; Losses in Fire Hydrants; Throttling Gates to Conserve Water; Foundry Rejections of Cast-Iron Pipe."

The paper was discussed by Mr. R. C. P. Coggeshall, Mr. Frank A. Barbour, Mr. Frank A. McInnes, Mr. Carleton E. Davis, Mr. William R. Conard, Mr. Kunhardt, and Mr. H. O. Lacount.

Mr. George A. Sampson, civil engineer, Boston, Mass.; read a paper entitled, "The Middleboro, Mass., Reinforced Concrete Tower Tank."

Adjourned.

EXECUTIVE COMMITTEE.

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Mass., at 11 o'clock A.M., Wednesday, November 10, 1915.

Present: William F. Sullivan, Charles W. Sherman, Edwin C. Brooks, Richard K. Hale, Lewis M. Bancroft, George A. King, and Willard Kent; Vice-President Sullivan presiding.

Fourteen applications for active membership were received, viz., Horace Belden, president and manager Simsbury Water Company, Simsbury, Conn.; Hazen G. Pillsbury, service clerk, Water Department, Lowell, Mass.; Homer R. Turner, superintendent Water Department, the Windsor Fire District, Windsor, Conn.; F. O. Eichelberger, city engineer, Dayton, Ohio; Dow R. Gwinn, president and manager Terre Haute Water Company, Terre Haute, Ind.; John Gaub, Washington, D. C.; C. L. Kirk, president Indianapolis Water Company, Indianapolis, Ind.; Ernest B. Bain, superintendent water works, Raleigh, N. C.; Chas. H. Fischer, Jersey City, N. J.; Frank E. Hale, director of laboratories, Department Water Supply, Gas, and Electricity, New York City; J. Arthur Durst, Philadelphia, Pa.; M. Z. Bair, assistant engineer, State Board of Health, Columbus, Ohio; Thomas Grieve, Perth Amboy, N. J., and Homer F. Cox, Scranton, Pa.; one for associate, viz., Lock Joint Pipe Company, New York, N. Y., and they were by unanimous vote recommended therefor.

President Metcalf was, by vote, authorized to appoint a representative of the Association to attend the Second Pan-American Scientific Congress at Washington, D. C., December next, and an expenditure not to exceed fifty dollars is to be allowed for his expenses.

The report of the Committee of Arrangements of the last annual convention was received, read, and placed on file.

The report of the Committee on Memoir and Memorial of the late Dexter Brackett, President of the Association 1889–90, was presented, read, and ordered presented to the Association with

the recommendation of the Executive Committee that the suggestions therein be adopted and a committee appointed for their consummation.

A communication from the chairman of the Committee on Dimensions and Specifications of the Committee of Manufacturers on Standardization of Fittings and Valves, with reference to standard specifications, was read, and it was voted that the matter be presented to the Association.

The Committee on Engineering Coöperation, viz., Messrs. Carleton E. Davis, William F. Sullivan, and George W. Batchelder, reported that " the committee has considered the matter carefully and its conclusions are to the effect that the Association should not at this time take definite steps toward joining in the movement for engineering coöperation.

Adjourned.

Attest: WILLARD KENT, *Secretary.*

Meeting of the Executive Committee of the New England Water Works Association at headquarters, Tremont Temple, Boston, Mass., December 8, 1915, at 11 o'clock A.M.

Present, Carleton E. Davis, George F. Merrill, Charles W. Sherman, William F. Sullivan, Edwin C. Brooks, Samuel E. Killam, Lewis M. Bancroft, George A. King, and Willard Kent.

Nine applications for membership were received and they were by unanimous vote recommended therefor.

Charles F. Farnham, superintendent Collinsville Water Company, Collinsville, Conn.; Thomas C. Atwood, consulting engineer, New Haven, Conn.; J. Frederick Jackson, consulting engineer, New Haven, Conn.; F. Spencer Goodwin, water commissioner, Hartford, Conn.; John Franklin, consulting engineer, Andover, Mass.; Henry T. Sawyer, inspector and foreman Metropolitan Water Works, Brighton, Mass.; William N. Davenport, secretary, Metropolitan Water and Sewerage Board, Newton, Mass.; William E. Whittaker, civil engineer, Metropolitan Water Works, Boston, Mass.; W. Dayton Frederick, commissioner Public Works, Bridgeton, N. J.

Adjourned.

Attest: WILLARD KENT, *Secretary.*

DEXTER BRACKETT.

PAST PRESIDENT, NEW ENGLAND WATER WORKS ASSOCIATION.
Died August 26, 1915.

DEXTER BRACKETT, as one of the early members of the New England Water Works Association, and at various times Vice-President, President, Senior Editor, Secretary *pro tem.*, and member of the Executive Committee, has an unique place in the history of the Association. Although his face, once so familiar, will no longer reflect his kindly spirit in the meetings, his inspiration, the benefits of his clear foresight, and the results of his efforts to keep the Association on the right road to usefulness, will long continue. As a friend many a member, younger and elder, will long cherish his memory. Some of his earlier *confrères* in the Association thus write of him:

"Dexter Brackett joined our Association in 1885, was made a Vice-President in 1889, President in 1890, a member of the Executive Committee in 1891, and an Editor of our JOURNAL during the years 1892, 1893, 1894, and 1895. He contributed his first paper in 1886, and till his death took a very active interest in the affairs of the Association, contributing greatly to its success by furnishing valuable papers himself and by ably discussing those presented by others. These accomplishments are matters of record; other work of his, unrecorded and not generally known, but as valuable, in my opinion, as any he ever did for the Association, was that performed by him in bringing into our ranks many men eminent in the engineering profession." — *Albert S. Glover.*

"I first became acquainted with Dexter Brackett in the early eighties. A little later (April, 1885) he joined the New England Water Works Association. A personal friendship with the writer then gradually developed that remained undiminished as long as he lived. He first appeared before the Association with a paper concerning water waste, in 1886, after which he frequently contributed to the literature and discussions of the society. He set a high standard and secured many valuable papers for the meet-

ings. I was Secretary of the Association during his term as President, and thus came in frequent contact with him. He was an indefatigable worker for the interests of the Association, and he always produced results. It was a pleasure and satisfaction to work with a man of such convincing ideas. He put a tremendous amount of labor into the work of his administration. There was no lack of inspiration while his hand was at the helm. He was a working president in every sense that the word implies. When I was finally compelled to resign the secretaryship in 1895 he took up my work as Secretary *pro tem.* in addition to his duties as Editor, and continued for a month until a new Secretary was elected. Mr. Brackett possessed a broad outlook, a keen mind, and, above all, a sanity of view that was always helpful to those not so well informed, and he was generous in helping others. He was loyal to the public welfare in an exceptional degree. He possessed a high standard of what was due to the public, and he rendered that service faithfully and competently. What he was to all who knew him a little while ago he will always be to them now, one to mourn because he has gone away, one to remember always with exceeding joy." — *R. C. P. Coggeshall.*

"I remember Mr. Brackett very well when the New England Water Works Association was first formed. He was connected with the distribution system of the Boston Water Works, and naturally took much interest in matters connected with piping plans. He frequently added to the value of papers and discussions by his accurate knowledge and enthusiastic interest. I think he was one of the first to study seriously the growing dangers from waste of water in public supplies, and the literature of this branch of water-works engineering owes much to his investigations. I was associated with him for many years and should like to bear testimony to the constant progress which he made in his professional career. He was indefatigable in the pursuit of knowledge, and continued his work to the very last with but few intermissions." — *Desmond FitzGerald.*

"In the long backward look of something like thirty years, I recall Dexter Brackett as one of the notable men in the early history of the New England Water Works Association. Tall, clean-shaven, rather spare in figure, he was once referred to by some one in Boston who did not know him as that long-legged schoolboy who told you what you could or could not have in the line of water-supply. Youthful he was in appearance, in those early days when he discovered underground leaks in the Boston street mains, by the Deacon method. But his skill, discretion, and clear thinking were not those of the average youngster, and

his ability soon brought the recognition that it so well deserved. Pleasant he was, courteous and kindly, and fortunate were those who worked with, and knew him." — *Wm. R. Billings.*

Dexter Brackett, the only son of Cephas Henry and Louisa Thwing (Pierce) Brackett, was born November 30, 1851, in Newton, Mass. During his childhood, his parents removed to the adjoining town of Brighton, which subsequently became a part of the City of Boston. He was educated in the town schools and graduated from the Brighton High School in 1868. In 1868–1869 he took a six months' course at a business college.

As is the case with many young men, he had no well-defined plan as to his life work, but in March, 1869, age seventeen years, an opportunity was presented for his employment in the city engineer's office, Boston, and as engineering appeared to him a desirable line of work, he accepted the position. The time proved to be a favorable one, as the city engineer's office had been recently reorganized, and the great increase in the territory of the city by the annexation of several towns, one after another, from 1868 to 1874, caused a large increase in the engineering work to be done, with corresponding opportunities for promotion. Only one of the five municipalities annexed was provided with a public water supply, and Mr. Brackett was soon assigned to the work incident to the extension of the pipes into these municipalities and the establishment of a new high-service system of supply. The great fire in Boston in November, 1872, also called urgent attention to the necessity for a more adequate system of main pipes in the city proper.

One of the most noteworthy events in the early part of Mr. Brackett's professional career, as well as in the careers of many of his associates, was the election of Mr. Joseph P. Davis as city engineer of Boston, in the spring of 1873. His personality and the high grade of his professional work molded to a large extent the subsequent careers of those under him. The office served as a most valuable training school, both in engineering and in ethics, a fact which was fully recognized by Mr. Brackett during his life, as well as by many of his associates.

Under Mr. Davis's direction, Mr. Brackett was early placed in charge of the distribution system of the water works. In

addition to the large amount of work done in extending and reinforcing the water-pipe system in those years, the question of the waste of water soon came to the front, on account of the increasing water consumption, and as early as 1878 Mr. Brackett began a study of this problem for Mr. Davis. At that time, although the waste of water was recognized as a very important factor, it was not nearly as large as in subsequent years. Water meters were then much more expensive and less durable than at the present time, so that the remedial measures proposed were in the line of the restriction of waste through its detection by inspection, aided by the use of Deacon meters. Church stopcocks and Bell waterphones were also tried as aids in this work. In the next few years, Deacon meters were set in some districts of the city, and a very marked reduction in the consumption and waste of water resulted. Thus Mr. Brackett became especially interested in the consumption and waste of water, and an authority upon the subject. In addition to material prepared for the official city reports, he presented a paper on the subject to the New England Water Works Association in 1886 and to the American Society of Civil Engineers in 1895.

During Mr. Brackett's long connection with the Boston Water Works, which continued until August 1, 1895, he had experience with every phase of water distribution. His work included not only engineering, but duties as superintendent in direct charge of the constructing and operating forces, from February, 1888, to June, 1891, and covered such features as the laying of pipes across navigable streams, the raising of large mains while full of water, the cleaning of tuberculated pipes, the testing of fire engines and fire boats, the construction of a high-pressure system of piping for fire protection only, the installation and testing of heavy pumping machinery, and the construction of distributing reservoirs.

In 1895, he was asked by the State Board of Health of Massachusetts to advise as to the present and future consumption of water per inhabitant in the Metropolitan Water District, and made a valuable report.* His predictions made in 1894 as to the

* Special Report, State Board of Health of Massachusetts, on a Metropolitan Water Supply, 1895, page 157.

probable water consumption per inhabitant thirty years later now seem likely to be verified. In 1904 he made a very complete report to the Metropolitan Water and Sewerage Board,* on the measurement, consumption, and waste of water supplied to the Metropolitan Water District, which was transmitted to the state legislature as a basis for action in regard to the restriction of waste.

On August 1, 1895, the engineering force of the Metropolitan Water Works was organized, and Mr. Brackett, on account of his preëminent qualifications for the place, was selected as engineer of the Distribution Department, in charge of the construction of the pipe lines, pumping stations, and reservoirs in the Metropolitan Water District. The essential parts of the works were planned and executed rapidly and well, and had advanced far enough by January 1, 1898, the date fixed in the legislative act, to permit the water to be conveyed to all parts of the district. The pumping stations constructed and maintained for many years under this direction are regarded by many who have visited them as models in respect to economy and efficiency.

On February 1, 1907, Mr. Brackett became chief engineer of the Metropolitan Water Works, and held this position to the time of his death. In this capacity his duties related largely to the maintenance and operation of systems already constructed, a kind of work which he enjoyed. He was very successful in selecting his assistants in charge of the various portions of the works, and under his supervision an extremely efficient and loyal force was developed. There were, however, during this time important additions to the works, among which may be particularly mentioned the hydro-electric plant at the Wachusett Dam in Clinton; the forty-million-gallon high-service pumping engine at Chestnut Hill; the sixty-inch cast-iron pipe line from Weston to Chestnut Hill Reservoir, including the pressure tunnel through a hill in Newton; the improvement of the water supply for the elevated districts in Boston, Hyde Park, and Milton, including the pumping station at Hyde Park and the steel tank on Bellevue Hill one hundred feet in diameter and forty-five feet high, surrounded by a

* Annual Report, Metropolitan Water and Sewerage Board, January 1, 1904, page 301. Also JOURNAL N. E. W. W. ASSOCIATION, 1904, Vol. XVIII, page 107.

masonry tower; and the hydro-electric plant at the Sudbury Dam in Southboro now in process of construction.

One important reform has taken place on the Metropolitan Water Works since he became chief engineer, namely, the introduction of water meters. This resulted largely from reports written by him upon the subject of consumption and waste of water, and from his persistent advocacy of the use of meters within the Metropolitan Water District as a means of reducing waste. He had the privilege of seeing his views adopted and the consumption of water thereby greatly decreased. Up to 1907, the consumption had been increasing so rapidly as to point out the necessity for an additional supply within the next few years, but the gradual introduction of meters reduced the consumption so rapidly that no additional supply will be needed for many years, the consumption now being less than two thirds of what it would have been had the former rate of increase continued.

In addition to his regular engineering work, Mr. Brackett was called as an expert in connection with water supplies at Fall River, Stoughton, Taunton, New Bedford, Ashburnham, and Springfield, Mass.; Auburn, Me.; Syracuse, N. Y.; Atlantic City, N. J.; Louisville, Ky.; Springfield, Mo.; Harbor Springs, Mich.; and other places, in several cases in connection with the testing of pumping engines or the valuation of the works. He ceased to accept the many engagements offered him along these lines after 1895, at first because the Metropolitan Water Works demanded all of his time, and later because a diminishing vitality made it undesirable for him to accept the burden of work in addition to that required by his regular duties.

In all, Mr. Brackett served the City of Boston and the Metropolitan Water District for forty-six years, most of the time in positions of much responsibility. Taking into account his entire trustworthiness and loyalty to his work, and his special ability in the branches of water-works engineering in which he was engaged, it is difficult to over-estimate the value of the public service which he rendered during his long professional career.

Mr. Brackett was a director of the American Society of Civil Engineers, 1908–1910; president of the Boston Society of Civil Engineers, 1897–1898; president of the New England Water Works

Association, 1889–1890; and a member of the American Water Works Association and the Boston City Club.

Some of the more important papers contributed by him to the technical societies, in addition to those on the subject of the consumption and waste of water already referred to, related to the raising or otherwise moving of large water mains, the consumption of water at a large fire in Boston on November 28, 1889, the tuberculation of water pipes, the freezing of fresh water in a pipe submerged in salt water, and a description of the Metropolitan Water Works, presented to the American Water Works Association. He was an important member of the committee of the New England Water Works Association which prepared standard specifications and drawings for cast-iron water pipes and special castings. The specifications and plans were adopted by the Association on September 10, 1902.

On September 21, 1875, Mr. Brackett married Miss Josephine Dame, who survives him. He also leaves one son.

Mr. Brackett was elected a member of the New England Water Works Association April 21, 1885; was a Vice-President, 1888–89; President, 1889–90; and Senior Editor, 1891–95.

FREDERIC P. STEARNS,
ALFRED D. FLINN,
ALLEN HAZEN,
Committee.

JOURNAL

OF THE

New England Water Works Association.

VOLUME XXIX.

1915.

PUBLISHED BY
THE NEW ENGLAND WATER WORKS ASSOCIATION
715 TREMONT TEMPLE, BOSTON, MASS.

The four numbers composing this volume have been separately copyrighted in 1915 by the New England Water Works Association.

The Fort Hill Press
SAMUEL USHER
176 TO 184 HIGH STREET
BOSTON, MASS.

INDEX.

Air pumped from suction mains. D. N. TOWER. 161, June.
American Water Works Association. Members admitted to New England Water Works Association without payment of an initiation fee. 147, March; 230, June.
Asphalt and felt waterproof coating for concrete.
Standpipe at Attleboro, Mass. H. F. CONANT. 182, June.
Standpipe at Westerly, R. I. THOMAS MCKENZIE. 176, June.

Bacteria.
Ozone as a sterilizing agent. S. T. POWELL. 87, March.
Ultra-violet rays for water purification. M. VON RECKLINGHAUSEN. 202, June.
Blatt, M. Laying water pipes in congested streets. 513, Dec.
Brick wall about the concrete standpipe at Attleboro, Mass. H. F. CONANT. 183, June.

Color. Removed from water by ozone. S. T. POWELL. 87, March.
Conant, H. F. Attleboro's reinforced concrete standpipe. 179, June.
Concrete.
Formula 1: 1: 2 impervious to water. H. B. ANDREWS. 188, June.
Grout used to repair leaks. G. F. MERRILL. 158, June.
Leadite used to prevent seepage. LINCOLN VAN GILDER. 576, Dec.
Reservoirs on Glen Brook and Green River for the supply of Greenfield, Mass. G. F. MERRILL. 149, June.
Concrete, reinforced.
Electrolysis and its mitigation. E. B. ROSA. 49, March.
Standpipe at Attleboro, Mass. H. F. CONANT. 179, June.
Standpipe at Westerly, R. I. THOMAS MCKENZIE. 169, June.
Standpipes. (Discussion.) 184, June.

Efficiency dependent on personal character. C. H. EGLEE. 214, June.
Eglee, Charles H. Personal character in its relation to practical efficiency. 214, June.
Electricity. Electrolysis and its mitigation. E. B. ROSA. 49, March.

Filter beds used to protect a collecting well from swamp water. D. N. TOWER. 163, June.
Filter gallery near Lily Pond used for auxiliary supply for Cohasset, Mass. D. N. TOWER. 163, June.

Filtration galleries dependable under proper conditions. ALEXANDER POTTER. 548, Dec.

Fire protection.

Breaks in large sprinkler connections a cause of low pressure at the Salem, Mass., fire. F. A. MCINNES and CLARENCE GOLDSMITH. 94, March.

Fire-hydrant rental. B. M. WAGNER. 1, March.

Greenfield, Mass., fire supply. G. F. MERRILL. 149, June.

Gates operated by electricity from a distance. ALFRED WILLIAMSON. 507, Dec.

Goldsmith, Clarence. Salem fire. 94, March.

Goodnough, X. H. Rainfall in New England. 237, Sept.

Grounding secondary circuits of transformers on water pipes. E. B. ROSA. 67, March.

Grout used to repair leaks in concrete. G. F. MERRILL. 158, June.

Havill, H. T. Pump slip tests as an aid to efficiency in the operation of pumping engines. 511, Dec.

Honness, George G. Sanitary improvement of a large watershed. 502, Dec.

Hooper, Elmer G. Location of leaks in submarine pipe lines. 536, Dec.

Insulating property of Leadite. W. C. HAWLEY. 573, Dec.

Joints. Leadite joints for water pipes. H. A. SYMONDS. 557, Dec. W. C. HAWLEY. 563, Dec.

Kensico Dam. W. F. SMITH. 489, Dec.

Laase, William F. Brooklyn water supply. 546, Dec.

Laws.

Some provisions of the California public utilities act. 16, March.

Some provisions of the Wisconsin public utility law. 15, March.

Leadité.

Leadite joints for water pipes. H. A. SYMONDS. 557, Dec. W. C. HAWLEY. 563, Dec.

Leadite used in connection with concrete construction. LINCOLN VAN GILDER. 576, Dec.

Leaks. Location of leaks in submarine pipe lines. E. G. HOOPER. 536, Dec.

McInnes, Frank A. Salem fire. 94, March.

McKenzie, Thomas. Standpipe at Westerly, R. I. 169, June.

McMurray, James A. Metering an old city. 73, March.

Memoir. Brackett, Dexter. 592, Dec.

Merrill, George F. Greenfield water works. 149, June.

Nelson, Fred B. Testing meters with reference to curves of accuracy and friction loss. 539, Dec.

New England Water Works Association.
Address by President McInnes. 136, March.
Address by President Metcalf. 226, June; 462, Sept.
Address by Police Commissioner Woods of New York. 448, Sept.
Address by C. N. Chadwick. 451, Sept.
Address by Dr. Allan J. McLaughlin, Commissioner of Health of Massachusetts. 123, March.
Address by D. F. Wilcox. 457, Sept.
Address by N. S. Hill. 461, Sept.
By-Laws, Article III, Section 1, amended to remit an initiation fee to members of the American Water Works Association. 232, June.
Committees appointed:
Dexter Brackett Memorial. 471, Sept.
Leakage of pipe joints. 468, Sept.
Loss of water. 229, June.
Nomination of officers. 467, Sept.
Service pipes, 145, March; 229, June.
Election of honorary members, 142, March; 471, Sept.
Election of officers. 139, March.
Proceedings:
Annual meeting. 121, March.
February meeting. 140, March.
March meeting. 226, June.
June meeting. 439, Sept.
September meeting. 443, Sept.
November meeting. 577, Dec.
December meeting. 584, Dec.
Executive committee, 1915:
Jan. 13. 146, March.
Feb. 10. 146, March.
March 10. 234, June.
April 7. 477, Sept.
May 7. 234, June.
June 16. 477, Sept.
Sept. 7. 477, Sept.
Sept. 8. 478, Sept.
Sept. 9. 479, Sept.
Nov. 10. 590, Dec.
Dec. 8. 591, Dec.
Principal statistics. 129, March.
Reports:
Committee on convention funds rules. 235, June.
Committee on Dexter Brackett memorial. 579, Dec.

Committee on engineering coöperation. 591, Dec.
Editor. 132, March.
Secretary. 126, March.
Treasurer. 130, March.
Auditing committee. 136, March.

Odors of waters affected by ozone. Effect of ozone upon odors in water. S. T. POWELL. 88, March.
Ozone as a sterilizing agent for water purification. S. T. POWELL. 87, March.

Pipes laid in congested streets, New York City. M. BLATT. 513, Dec.
Powell, S. T. Ozone as sterilizing agent. 87, March.
Pump slip tests as an aid to efficiency, H. T. HAVILL. 511, Dec.

Rainfall.
Precipitation in the Croton and Catskill watersheds as affected by altitude and winds. G. G. HONNESS. 433, Sept.
Rainfall in New England. X. H. GOODNOUGH. 237, Sept.
Rates of return allowed to water companies by sundry judicial decisions. 21, March.
Recklinghausen, M. von. Ultra-violet rays for water purification. 202, June.
Reservoirs.
Greenfield, Mass. G. F. MERRILL. 150, June.
Grubbing about Kensico reservoir. G. A. WINSOR. 554, Dec.
Kensico reservoir. W. F. SMITH. 486, Dec.
Rosa, Edward B. Electrolysis and its mitigation. 49, March.

Sanitary improvement of a large watershed in the Catskill region. G. G. HONNESS. 502, Dec.
Smith, J. Waldo. Present status of the Catskill water supply for New York City. 481, Dec.
Smith, William Fitch. Kensico reservoir. 486, Dec.
Standpipes.
Concrete standpipes. (Discussion.) 184, June.
Reinforced concrete standpipe at Westerly, R. I. THOMAS MCKENZIE. 169, June.
Table of data. 186, June.
Suter, Russell. Control of public water supplies by the Conservation Commission of the State of New York. 520, Dec.
Symonds, Henry A. Leadite joints for water pipes. 557, Dec.

Tower, D. N. Water supply system of Cohasset, Mass. 160, June.

Valve intended to check the flow of water in tunnel shafts under New York City. A. D. FLINN. 113, March.

Wagner, Bernard M. Rates for water supply. 1, March.

Water.

Control of public water supplies by the Conservation Commission of the State of New York. RUSSELL SUTER. 520, Dec.

Ozone as a sterilizing agent for water purification. S. T. POWELL. 87, March.

Rates for water supply. B. M. WAGNER. 1, March.

Ultra-violet rays for water purification. M. VON RECKLINGHAUSEN. 202, June.

Water meters.

Metering an old city, Boston, Mass. J. A. MCMURRAY. 73, March.

Testing meters with reference to curves of accuracy and friction loss. F. B. NELSON. 539, Dec.

Water works.

Attleboro, Mass. Reinforced concrete standpipe. H. F. CONANT. 179, June.

Boston, Mass. Metering an old city. J. A. MCMURRAY. 73, March.

Brooklyn, N. Y., water supply. W. F. LAASE. 546, Dec.

Cohasset, Mass. D. N. TOWER. 160, June.

Greenfield, Mass. G. F. Merrill. 149, June.

New York City:

Electrically operated valves on the high-pressure system. ALFRED WILLIAMSON. 507, Dec.

Grubbing about Kensico reservoir. G. A. WINSOR. 554, Dec.

Kensico reservoir. W. F. SMITH. 486, Dec.

Laying water pipes in congested streets of lower Manhattan. M. BLATT. 513, Dec.

Present status of the Catskill water supply. J. W. SMITH. 481, Dec.

Problems of revenue. D. F. WILCOX. 457, Sept.

Sanitary improvement of the drainage area of Ashokan reservoir. G. G. HONNESS. 502, Dec.

Westerly, R. I., standpipe. THOMAS MCKENZIE. 169, June.

Waterproofing a concrete standpipe by lining it with Neponset compound and water dyke felt. THOMAS MCKENZIE. 176, June.

Wells.

Covered concrete collecting well for Greenfield, Mass. G. F. MERRILL. 154, June.

Driven wells about Cohasset, Mass. D. N. TOWER. 160, June.

Wells used on Brooklyn supply system. W. F. LAASE. 546, Dec.

Williamson, Alfred. Electrically operated valve installations. 507, Dec.

Winsor, George A. Grubbing a large reservoir. 554, Dec.

Metcalf & Eddy

14 Beacon Street, Boston, Mass. — Harris Trust Building, Chicago, Ill.

WATER SUPPLY AND SEWERAGE

Design — Construction
Supervision — Management
Reports — Valuations

WILL J. SANDO

Consulting, Hydraulic, Efficiency and Organization Engineer. Specifications, plans, inspection and tests for water works, hydro-electric and high-pressure fire service pumping plants.

629 Wells Building
MILWAUKEE, WIS.

NICHOLAS S. HILL, Jr., and S. F. FERGUSON

Consulting Engineers, Water Supply and Sewage Disposal. Evaluations and Reports. Laboratory for Analysis of Water and Sewage and for Testing Cement, Sand, Coal, and Metals. Steam and Hydraulic Power Plants.

100 Williams Street, New York

WILLIAM R. CONARD

Assoc. Amer. Soc. C. E. — Assoc. Mem. Amer. Soc. M. E.

322 High St., Burlington, N. J.

Inspections and Tests of Materials

SOUTHERN OFFICE

Maison Blanche Bldg., New Orleans, La.

R. C. HUSTON, C.E., Special Representative

INDEX OF ADVERTISERS.

	PAGE.
Ashton Valve Co.	xv
Buffalo Meter Co.	ix
Builders Iron Foundry	xi
Chadwick-Boston Lead Co.	xxiv
Chapman Valve M'f'g Co.	xviii
Clarke, H. W. Co.	xii
Coffin Valve Co.	xxv
Conard, Wm. R.	i
Dixon, Jos. Crucible Co.	xii
Donaldson Iron Co.	xxi
Eddy Valve Co.	xx
Engineering Record, The	xxviii
Fox, John & Co.	xxiii
Hayden, James F.	xii
Hays M'f'g Co.	xiii
Hersey M'f'g Co.	iv
Hill, Nicholas S., Jr., & S. F. Ferguson	i
Lead Lined Iron Pipe Co.	xxiii
Leadite Co.	xxvi
Lock Joint Pipe Co.	xxvii
Ludlow Valve M'f'g Co.	xvii
Macbee Cement-Lined Pipe Co.	xv
Metcalf & Eddy	i
Mueller, H. M'f'g Co.	xiv
National Meter Co.	ii, iii
National Water Main Cleaning Co.	xii
Neptune Meter Co.	vi
New York Continental Jewell Filtration Co.	xxi
Norwood Engineering Co.	xv
Pitometer Company	x
Pittsburg Meter Co.	vii
Rensselaer Valve Co.	xix
Ross Valve M'f'g Co.	xv
Sando, W. J.	i
Smith, The A. P. M'f'g Co.	xxiii
Smith, B. F. & Co.	xii
Staples, George T.	xv

(Index continued on page xvii.)

Water Meters

FOR ALL WATER WORKS SERVICE

All Sizes, 5-8 to 60 inches

CROWN

EMPIRE

NASH

GEM

PREMIER

With the only reliable straight-reading register in the market

National Meter Company

84-86 CHAMBERS STREET

NEW YORK CITY

BOSTON 159 Franklin St. | CHICAGO 1223 Wabash Ave. | PITTSBURG 4 Smithfield St. | LOS ANGELES 411 So. Main St.

CINCINNATI 10 West Third St. | SAN FRANCISCO 681 Market St.

The NASH
GAS ENGINE and TRIPLEX PUMP

FOR
Town and Village Water Works and Pumping Service Generally

CAN BE ADAPTED FOR EITHER GAS OR GASOLENE

National Meter Company
84-86 CHAMBERS STREET, NEW YORK

BOSTON: 159 Franklin Street
PITTSBURG: 4 Smithfield Street
CINCINNATI: 10 West Third Street
CHICAGO: 1223 Wabash Ave.
SAN FRANCISCO: 681 Market Street
LOS ANGELES: 411 South Main Street

APPROVAL

HERSEY DETECTOR METER

The Hersey Detector Meter has been accepted for eleven years in 3", 4", 6", 8", 10" and 12" sizes without any restrictions or conditions of any kind by every Insurance Company, Stock and Mutual, doing business in the United States, and by the Water Departments and Water Companies in more than 500 Cities and Towns for use on over 3,000 Fire Services protecting nearly $2,000,000,000. worth of Insured Property.

HERSEY MANUFACTURING COMPANY

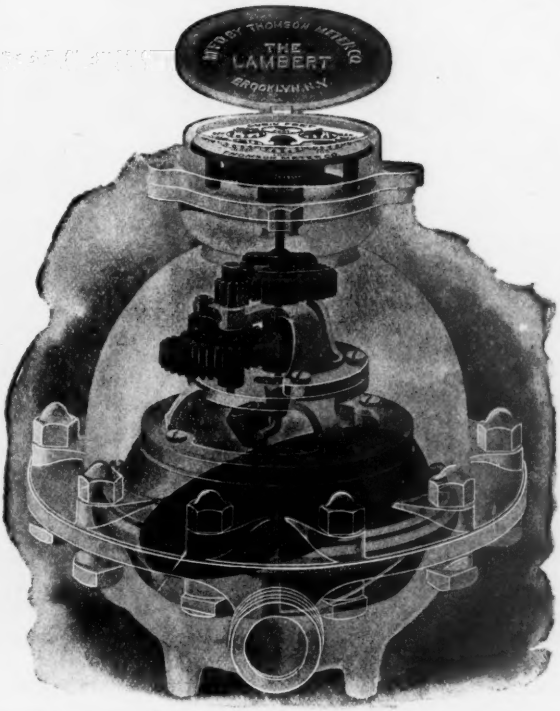
BOSTON	COLUMBUS, O.	SAN FRANCISCO
NEW YORK	PHILADELPHIA	LOS ANGELES
CHICAGO	ATLANTA	PORTLAND, ORE.

ACCURACY, LONG LIFE,

Avoidance of Repairs

Are the Requisites of the Perfect Water Meter and are the Principal Features of the

"LAMBERT."



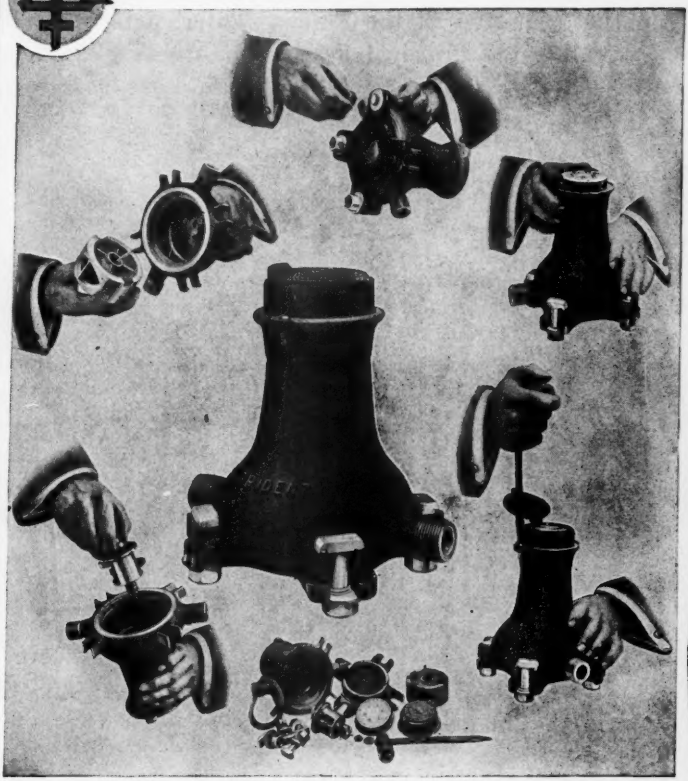
Our unbreakable disk-piston, reinforced with an internal steel plate, can be found only in the **LAMBERT METER.**

The growing popularity of the water-meter system is attributed by many to the inherent excellence of the **"LAMBERT"** meter. Where **"LAMBERT"** meters are selected, success is assured.

THOMSON METER CO.

100-110 BRIDGE ST.
BROOKLYN, N. Y.

TRIDENT WATER METERS



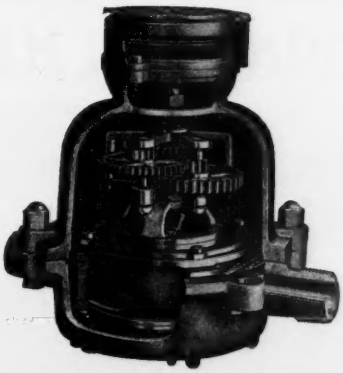
Assembling Simplicity of Trident Construction

The above cut shows a Trident-Disk Meter dismantled and the extreme ease with which it can be assembled, by first putting in the gear train, then the disk-chamber, the frost bottom next, then the register and register box and the meter is complete. The Trident combination wrench is the only tool necessary to use.

NEPTUNE METER COMPANY

90 WEST STREET NEW YORK

CHICAGO, BOSTON, SAN FRANCISCO,
ATLANTA, LOS ANGELES, PORTLAND, SEATTLE



"KEYSTONE" WATER METER

NEW YORK CHICAGO

Keystone and Eureka

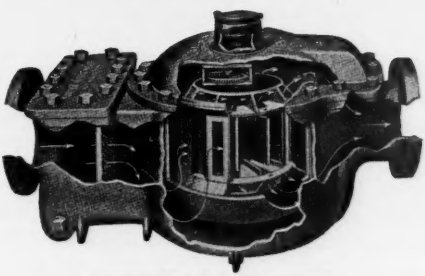
Water Meters

COLUMBIA, S. C. SEATTLE

Pittsburgh Meter Co.

East Pittsburgh, Pa.

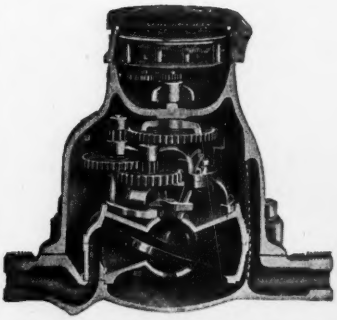
KANSAS CITY

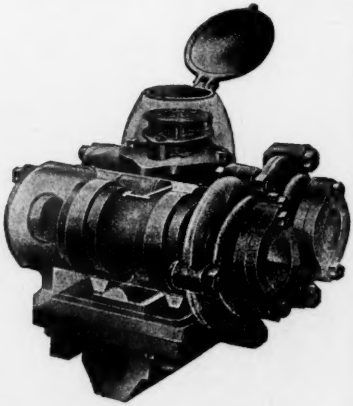


"EUREKA" WATER METER

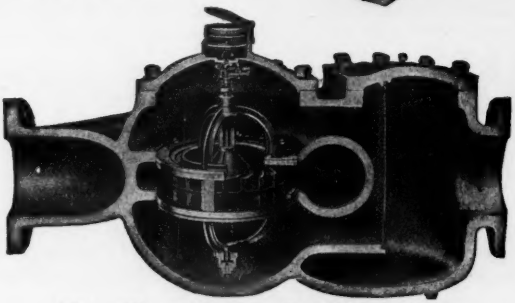
WORTHINGTON METERS

The Worthington Duplex Piston Meter is particularly adapted to large and heavy water works services.





The Worthington Disc Meter combines minimum weight with reliability on constant service and accuracy of registration.



The Worthington Turbine Meter is designed primarily to handle large volumes of water with minimum loss of pressure.

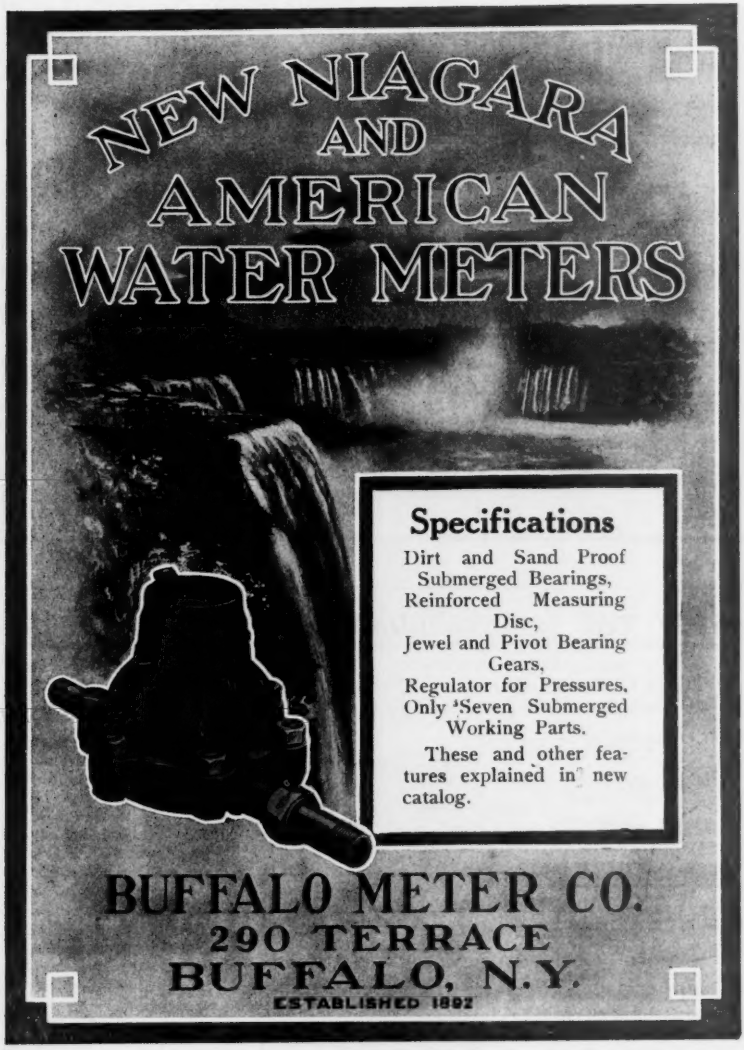
Full descriptions of the different types of Worthington Meters, with tables of sizes and capacities, are given in Bulletin W184–54.

HENRY R. WORTHINGTON

WORKS: HARRISON, N. J. :: New York Office: 115 Broadway

Boston Office: 465 John Hancock Building

W159.8



Distributers for New England

GEO. E. GILCHRIST CO.

106 HIGH STREET

BOSTON, MASS.

UNION ROTARY, COLUMBIA, DISC and NILO (Velocity) WATER METERS

Water Pressure Regulators
Waste Stops and Corporations

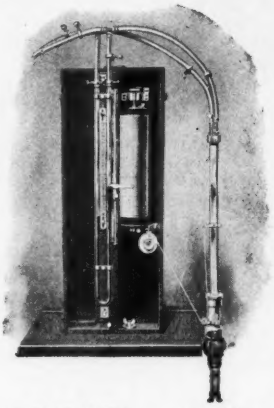
UNION WATER METER COMPANY
WORCESTER, MASSACHUSETTS

STOP THE UNDERGROUND WASTE OF WATER!

It is now known that UNDERGROUND leakage may be enormous. The PITOMETER is the most efficient Waste Meter known. Adopted by New York City, Washington, D. C., Chicago, St. Louis, Indianapolis, Pittsburgh, Memphis, etc.

PRISM
PHOTO RECORDERS
MANUAL RECORDERS
PUMP SLIP INDICATORS
STREET CONNECTIONS

The City of Washington, D. C., has found and stopped underground leakage amounting to over 30,000,000 gallons daily with our Pitometer. A saving worth $5,000,000 to the city.



The Pitometer is portable and will accurately indicate or record the flow of water in a pipe of any size, under any pressure, without cutting the main. Only a one-inch tap is needed.

We make water waste surveys for cities, or we sell or rent our instruments and help you to organize a Pitometer department of your own.

Write for Information

THE PITOMETER COMPANY, 25 Elm Street, New York

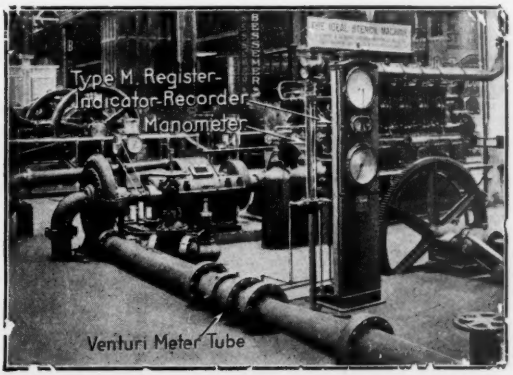
OF GOLD MEDAL PRESTIGE FOR TWENTY-TWO YEARS

THE fact that the Venturi Meter has been awarded a gold medal at the PANAMA-PACIFIC EXPOSITION is significant in itself, but when it is recalled that the

VENTURI METER

also received a gold medal at the World's Columbian Exposition at Chicago in 1893, at the Pan-American Exposition in Buffalo in 1901, and at the Universal Exposition in St. Louis in 1904, its prestige to-day becomes doubly significant.

Here it might be mentioned also that at the Chicago Exhibit, the Venturi Meter saved approximately $25,000 by disclosing a waste of water due to an open valve.



The illustration shows a Venturi Meter measuring water from the discharge of a centrifugal pump at the Pelton Doble Water Wheel Co.'s exhibit at the Panama-Pacific Exposition. Venturi Meters are an unfailing means of maintaining pumps at their initial efficiency. Let us send you Bulletin No. 83-W which explains why.

BUILDERS IRON FOUNDRY, PROVIDENCE, R. I.

"Builders of the Venturi"

NEW YORK PITTSBURGH CHICAGO SAN FRANCISCO PORTLAND SEATTLE

H. W. CLARK CO.

122 South Seventeenth St., Mattoon, Illinois, U.S.A.

BRANCH OFFICES
NEW YORK SAN FRANCISCO CHICAGO
MANUFACTURERS

The Clark Meter Box — Meter Testers, Service and Valve Boxes, Valve Housings, and most everything for the Water Department.

Send for catalogues, prices, etc.

Member of the American and New England Water Works Associations
12 years inspecting materials for the Dept's of Water, G. & E. and Bridges of New York City

JAMES F. HAYDEN

INSPECTION AND TESTS OF MATERIALS
1601 45th Street, Brooklyn, N. Y. City

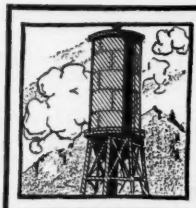
SPECIALTY:
Inspecting materials for high and low pressure water systems, gas conveyors, structural steel, and cast iron for buildings and bridges, railroad supplies

WM. F. WOODBURN

"STANDARD" CAST-IRON PIPE
SPECIAL CASTINGS
Estimates Free

TELEPHONE { Business Hours, 5951 Fort Hill
Nights and Holidays, 957-W, Malden

201 Devonshire Street, Boston, Mass.
Works — Bristol, Penn.



DIXON'S
Silica-Graphite
PAINT

"the longest service paint" for all metal surfaces.

BOOKLET NO. 87-B.

JOSEPH DIXON CRUCIBLE CO., Jersey City, N. J.

C. D. Kirkpatrick S. P. Gates
Established 1878

B. F. SMITH & CO.

Incorporated

Artesian and Driven Wells, Foundation Borings

Engineers and Contractors for Municipal and Private Water Works

First National Bank Building
60 Federal Street Boston, Mass

USE APPLICATION BLANK
On Last Poge of Advertisements

HELP PASS THE 1,000 MARK

?

?

ENOUGH WATER?

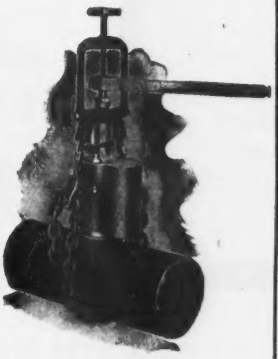
If not, it is probably because of lack of carrying capacity of your mains. Consult us.

Illustrated booklet upon request

NATIONAL WATER MAIN CLEANING CO.

50 Church Street New York City

Payne's Patent "NEW ECLIPSE" Tapping Machines

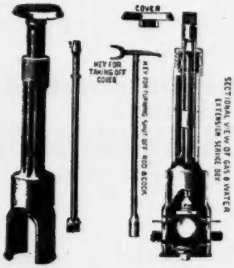


Do the best work, because they have

Few Working Parts
Compact
Simple in Construction
Light in Weight

We can prove these facts by sending a machine to you on thirty days' trial.

Long Main-End Corporation Cocks can be used



Makers of

High-Grade Water Works Brass Goods

to suit every requirement

Experience of hundreds of water companies has proven that original "HAYS-ERIE" SERVICE BOXES give the best satisfaction

Ask for Samples and Prices

Hays Manufacturing Co. Erie, Penna.

MUELLER
WATER TAPPING MACHINES

Mueller No. 2 Machine

Has your Company a MUELLER machine?

If not—why?

There isn't a better investment in the Water Works line.

One machine will last from 20 to 30 years; and with a very low cost of maintenance.

MUELLER machines are simple, efficient and convenient.

Every machine is Unconditionally Guaranteed.

Write us to-day for our booklet on tapping machines, and our liberal exchange proposition on your old machine, if you have one. Over 90% of the tapping machines in use in the United States are MUELLER machines.

H. MUELLER MFG. CO.

DECATUR, ILL.

NEW YORK CITY
CHICAGO
SAN FRANCISCO
SARNIA, ONT.

WATER
FILTERS
REGULATORS
& ENGINES

We make **Pressure Regulating Valves** for all purposes, steam or water.

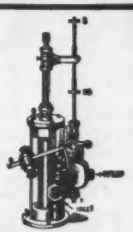
Our **Feed-Water Filter** will keep oil out of your boiler.

We can interest you if you use a condenser.

Water Engines for Pumping Organs

THE ROSS VALVE MFG. CO.

TROY, N. Y.



Standard for pumping church or parlor organs. Ask your organ builder for it or write us.

NORWOOD ENGINEERING CO.

FLORENCE, MASS.

MANUFACTURERS OF

"IMPROVED" WALKER FIRE HYDRANTS

ALSO THE OLD RELIABLE

"Holyoke" Gate Hydrant

LICENSED MANUFACTURERS OF

The Vivian Rate Controller

WRITE FOR CIRCULARS

CEMENT LINED SERVICE PIPES

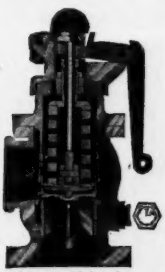
$8.80 (100 ft.) F. O. B. Boston

MACBEE CEMENT LINED PIPE CO.

BOSTON, MASS.

THE *Farmer's Almanac* says to every Water-Works Official who has service pipes that are not delivering an ample supply of water that this is the time of year to clean them with STAPLES' SERVICE PIPE CLEANER, used by Cambridge, Lowell, Newton, Nashua, Holyoke, and other cities and towns.

GEO. T. STAPLES, Dedham, Mass.



No. 20. Valve for Stationary Boilers.

They set the Pace

ASHTON POP VALVES and... STEAM GAGES

No. 74. Recording and Indicating Gage.

Superior in Quality of material and workmanship, and with greatest efficiency and durability, they challenge comparison with any others on the market. Send a trial order subject to approval ONLY IF SATISFACTORY, and thereby prove the claims made for them. HIGH GRADE GOODS OUR EXCLUSIVE SPECIALTY.

The ASHTON VALVE CO., 271 Franklin Street, BOSTON, MASS.

R. D. WOOD & CO.

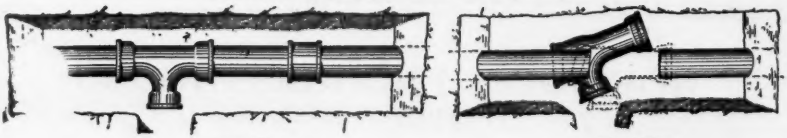
400 CHESTNUT STREET, PHILADELPHIA, PA.

Engineers, Iron Founders and Machinists

CENTRIFUGAL PUMPS
PUMPING ENGINES

Cast Iron Pipe

CUTTING-IN TEES

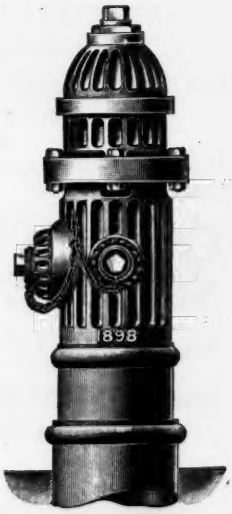


Old Way *Our Way*

Connections economically and easily made with one fitting. Saves sleeve, cuts, lead and unnecessary work and material.

"Reduced Specials"

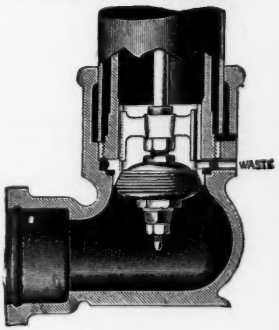
Cost of fittings reduced from 25% to 50%. Full strength. Deep bells. Convenient to handle. Sold by the piece.



Mathews Fire Hydrants

A half century of use has established their reputation as being the most economical, durable and simple hydrant.

Number in use exceeds total of all other makes combined.



Gate Valves

R. D. WOOD & CO. STANDARD
DOUBLE DISK
ANTI-FRICTION
EXTRA WEIGHT, FINISH
AND MATERIAL

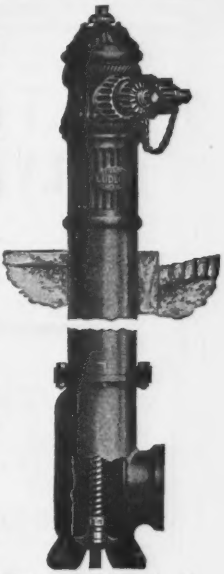
THE LUDLOW VALVE MFG. CO.

MANUFACTURERS OF

VALVES and FIRE HYDRANTS

This hydrant is anti-freezing, because when the drainage is good no water is left in it to freeze.

The drip is directly in the bottom of the hydrant and drains perfectly. It is protected by its valve, which never leaves its socket and cannot be clogged.



DOUBLE AND SINGLE GATE VALVES,

ALSO CHECK VALVES,

FOOT VALVES.

FIRE HYDRANTS.

YARD, WASH, AND FLUSH HYDRANTS.

☞ SEND FOR CIRCULARS. ☜

OFFICE AND WORKS: FOOT OF ADAMS STREET, TROY, N. Y.

BRANCH OFFICES:

NEW YORK	PHILADELPHIA	BOSTON	PITTSBURGH	CHICAGO	KANSAS CITY
62 GOLD ST.	HARRISON BLDG.	OLIVER BLDG.	1ST NAT. BANK BLDG.	THE ROOKERY	VICTOR BLDG.

INDEX OF ADVERTISERS (*Continued*).

	PAGE.
Thomson Meter Co.	v
Union Water Meter Co.	x
U. S. Cast Iron Pipe and Foundry Co.	xxii
Warren Foundry and Machine Co.	xix
Wood, R. D. & Co.	xvi
Woodburn, Wm. F.,	xii
Worthington, Henry R.	viii

CLASSIFIED DIRECTORY OF ADVERTISEMENTS.

ARTESIAN AND DRIVEN WELLS.

B. F. Smith & Co. . . . xii

BRASS GOODS.

Hays M'f'g Co. . . . xiii
H. Mueller Mfg. Co. . . . xiv
The A. P. Smith M'f'g Co. . . . xxiii
Union Water Meter Co. . . . x

CAST IRON PIPE AND SPECIALS.

Builders Iron Foundry . . . xi
Donaldson Iron Co. . . . xxi
John Fox & Co. . . . xxiii
U. S. Cast Iron Pipe and Foundry Co. . . . xxii
Warren Foundry and Machine Co. . . . xix
R. D. Wood & Co. . . . xvi
Woodburn, Wm. F. . . . xii

CEMENT-LINED PIPE.

Macbee Cement-Lined Pipe Co. . . . xv

(*Index continued on page xxv.*)

THE CHAPMAN VALVE MANUFACTURING COMPANY

Manufacturers of

Gate Valves Drip Valves

Gate Fire Hydrants

Corporation Cocks Curb Cocks

Anderson Couplings

Lead Pipe Connections

Trade

Mark

WRITE FOR OUR WATER-WORKS CATALOG

Main Office and Works
Indian Orchard, Mass.

BRANCH HOUSES

BOSTON, MASS. 141 High St.
NEW YORK CITY 180 Lafayette St.
PHILADELPHIA 1011 Filbert St.
CHICAGO 116 N. Jefferson St.

The "COREY" FIRE HYDRANT

MODERN
SUCCESSFUL
SIMPLE
DURABLE

SUPERIOR

RENSSELAER VALVES

ALL SIZES ALL PRESSURES

WATER, STEAM, GAS, OIL, ETC.

ELECTRICALLY OPERATED VALVES
Check Valves Air Valves
Indicator Posts Valve Boxes

CATALOGUE UPON APPLICATION

RENSSELAER VALVE CO., Troy, N. Y.

BRANCHES

NEW YORK, 180 Broadway PITTSBURG, 1102 House Bldg.
CHICAGO, 1108-9 Monadnock Block SEATTLE, 512 Colman Bldg.

ESTABLISHED 1856

WARREN FOUNDRY AND MACHINE CO.

Works at Phillipsburg, New Jersey
Sales Office, 11 Broadway, New York

Cast Iron Water and Gas

PIPE

From 3 to 60 inches in diameter

ALSO

All Sizes of Flanged Pipe and Special Castings

NEW ENGLAND REPRESENTATIVE

Messrs. F. A. HOUDLETTE & SON, Inc.

93 BROAD STREET, BOSTON, MASS.

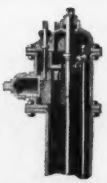
EDDY VALVE CO.

WATERFORD, NEW YORK, U.S.A.

PATENT RUBBER FACED

EDDY FIRE HYDRANT.

Section of Taper Seat-Valve.



Hydrant with Independent Nozzle Cut-off.

Section of Parallel Seat-Valve.

Section of Vertical Check-Valve.

Section of Vertical Foot-Valve.

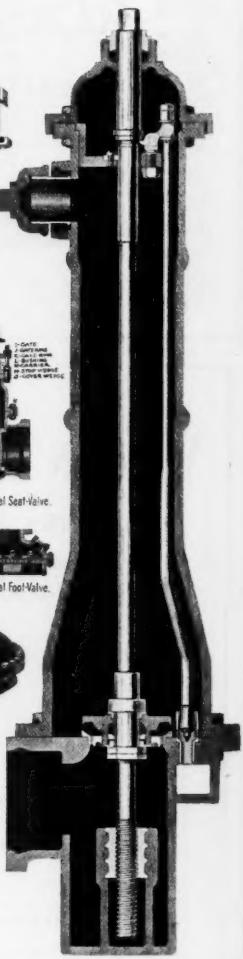
Horizontal Check-Valve.

Vertical Foot-Valve.

Hydrant with Water Crane Attachment.

Indicator Post.

Water Crane with Automatic Drip Valve.



VALVE OPEN—DRIP CLOSED.

All Goods made by the EDDY VALVE COMPANY are manufactured exclusively at WATERFORD, N.Y., U.S.A.

VALVE CLOSED—DRIP OPEN.

GRAVITY AND PRESSURE FILTERS

HYPOCHLORITE STERILIZING APPARATUS

Over 350 Municipal Plants in Successful Operation

Total Daily Capacity 900,000,000 Gallons

THE NEW YORK CONTINENTAL JEWELL FILTRATION CO.

15 BROAD STREET NEW YORK
111 W. MONROE STREET CHICAGO
313 E. TENTH STREET KANSAS CITY
619 NEW BIRKS BLDG. MONTREAL

EMAUS PIPE FOUNDRY, DONALDSON IRON CO.,

MANUFACTURERS
...OF...

CAST IRON PIPE

...AND ..

Special Castings for Water and Gas.
Also Flange Pipe, Street Castings,
Manhole Heads and Covers, etc.

JOHN D. ORMROD, President,
J. G. EBERLEIN,
Secretary and Treasurer.

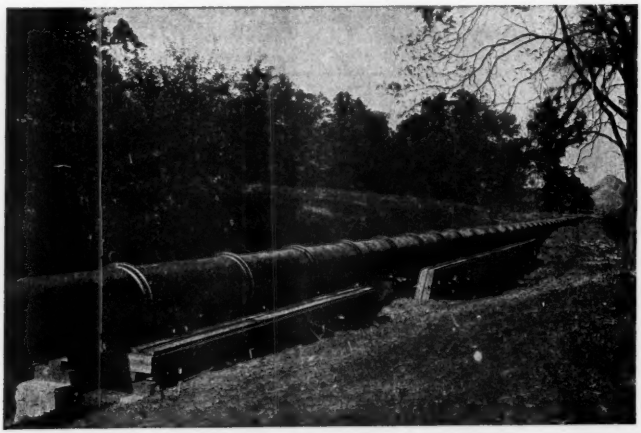
EMAUS,
LEHIGH COUNTY, PA.

CAST IRON PIPE

ALL REGULAR SIZES, 3 INCHES TO 84 INCHES

FOR WATER, GAS, SEWERS, DRAINS, ETC.

SEND FOR STANDARD SPECIFICATIONS



RAILROAD AND TURNPIKE CULVERTS

FLANGE PIPE AND FLANGE FITTINGS

HEAVY CASTINGS

AND THOSE MADE FROM ORIGINAL DESIGNS

United States Cast Iron Pipe and Foundry Company

SALES OFFICES

71 Broadway, New York City.
1421 Chestnut Street, Philadelphia, Pa.
Henry W. Oliver Building, Pittsburgh, Pa.
122 South Michigan Boulevard, Chicago, Ill.
520 Security Building, St. Louis, Mo.
James Building, Chattanooga, Tenn.
799 Monadnock Building, San Francisco, Cal.
Northwestern Bank Building, Portland, Ore.

THE A. P. SMITH MANUFACTURING CO.

EAST ORANGE, N. J.

Manufacturers of

Tapping Machines, Fire Hydrants, Water Gates,

Economic Lead Furnaces,

Corporation and Curb Cocks, Brass and Aluminum Castings.

Also General Supplies for Water and Gas Works.

Write for Catalogue.

NICHOLAS ENGEL

JOHN FOX & CO.

CAST IRON

WATER & GAS PIPES

FLANGE PIPE

Special Castings, Fire Hydrants, Valves

General Foundry and Machine Work

253 BROADWAY - - NEW YORK CITY

Postal Telegraph Building

HIGHEST AWARD, GOLD MEDAL,
ST. LOUIS EXPOSITION, 1904

Over 100 Water Departments

use

LEAD-LINED IRON and TIN-LINED PIPES

for their service connections

MANUFACTURED BY

Lead Lined Iron Pipe Company

Wakefield ═══════ Mass.

Chadwick-Boston Lead Co.

162 Congress St., Boston

Agents for

The Celebrated "ULCO"

LEAD WOOL

(Every Atom Pure Lead)

For calking pipe joints under the most difficult conditions.

For overhead joints, or in wet places where the use of molten lead is not only impracticable, but dangerous — **LEAD WOOL** may be employed to advantage. It makes perfectly tight joints to withstand the highest pressures, yet sufficiently elastic to admit of considerable sagging or settling of the pipe without causing the joint to leak. The difference in this respect, as compared with the poured joint, is notable.

NO FIRE — NO DANGER — NO TROUBLE.

Highest quality Lead Lined Iron Pipe and Fittings

***Also* Pure Block-Tin Lined Iron Pipe and Fittings**

Lead Pipe, Tin Lined Lead Pipe, Pure Block-Tin Pipe, Solder Pig Lead, White Lead and Red Lead

Coffin Valve Co.

BOSTON, MASS.

Manufacturers of Sluice Gates
Gate Valves
Check Valves
Flap Valves
Foot Valves
Fire Hydrants, etc.

SPECIAL ATTENTION PAID TO WATER-WORKS SUPPLIES FOR CITIES AND TOWNS

Send for Cuts and Prices of our

Type "B" Compression Hydrant and
Type "F" Gate Valves

Hydraulically and Electrically operated valves and sluice gates

CLASSIFIED DIRECTORY OF ADVERTISEMENTS (*Continued*).

	PAGE.
CLEANING WATER MAINS.	
National Water Main Cleaning Co.	xii
Staples, George T.	xv
FILTERS AND WATER SOFTENING PLANTS.	
New York Continental Jewell Filtration Co.	xxi
Norwood Engineering Co.	xv
Ross Valve M'f'g Co.	xv
FURNACES, ETC.	
H. Mueller Mfg. Co.	xiv
The A. P. Smith M'f'g Co.	xxiii
The Leadite Co.	xxvi
GAS ENGINES.	
National Meter Co.	iii
GATES, VALVES, AND HYDRANTS.	
Ashton Valve Co.	xv
Chapman Valve M'f'g Co.	xviii
Coffin Valve Co.	xxv
Eddy Valve Co.	xx
John Fox & Co.	xxiii
Ludlow Valve M'f'g Co.	xvii
Norwood Engineering Co.	xv
Rensselaer Valve Co.	xix
Ross Valve M'f'g Co.	xv
The A. P. Smith M'f'g Co.	xxiii
R. D. Wood & Co.	xvi
INSPECTION OF MATERIALS.	
Wm. R. Conard	i
J. F. Hayden	xii
LEAD AND PIPE.	
Chadwick-Boston Lead Co.	xxiv
Lead Lined Iron Pipe Co.	xxiii

(*Index continued on page xxix.*)

Twelve Reasons Why

YOU SHOULD USE

Trade "LEADITE" Mark

Registered U. S. Patent Office

FOR

Jointing Water Mains

1. **DURABILITY.** Leadite joints increase in strength with age.
2. **NO CAULKING.** Leadite joints require no caulking, because the Leadite adheres to the pipe, making a water-tight bond.
3. **COMPARATIVE QUANTITIES.** One ton of Leadite is equivalent to four tons of lead.
4. **LABOR SAVING.** Saves caulking charges and digging of large bell-holes, and reduces the cost of trench pumping to the minimum.
5. **COST.** Its use saves 50 to 65 per cent. over lead, owing to the saving effected in material and labor.
6. **TOOLS.** As no caulking is required, fewer tools are needed.
7. **TRANSPORTATION.** Considerable freight charges are saved because Leadite is lighter than lead.
8. **HAULING.** Saves hauling expense on the work because you move only one fourth the weight of jointing material.
9. **FUEL.** Saves fuel because you melt only one ton of material instead of four, and not as much heat is required either.
10. **DELIVERY.** We can make prompt shipments.
11. **DAMAGE SUITS.** Claims for damages caused by joints blowing out are prevented because Leadite joints will not blow out under any pressure.
12. **USERS.** Progressive water works all over the country use Leadite.

WRITE FOR BOOKLET

THE LEADITE COMPANY, Inc.

LAND TITLE BUILDING PHILADELPHIA

84-inch Intake made for Public Service Corporation of New Jersey

MERIWETHER SYSTEM = REINFORCED CONCRETE PIPE

Used by

Large Manufacturing Companies and others, for Intakes, Outlets, Culverts, Air Flumes, Cable Conduits, Underground Passages.

Used by

States, Counties, Towns, Cities, for Sanitary and Storm Sewers, Water Lines, Culverts, Drains, Wells.

JUST THE PIPE YOU HAVE BEEN LOOKING FOR

LOW COST — Made in your own city

HIGH EFFICIENCY — Keep your money at home

LOCK JOINT PIPE COMPANY

165 Broadway — New York City

THE CANADIAN LOCK JOINT PIPE CO., Limited
Regina, Sask., Can.

PACIFIC LOCK JOINT PIPE CO.
Tacoma, Seattle, Wash.

The Design and Construction of Water-Works Systems

and Novel Features in their Management are given careful attention by

THE Engineering Record

It also gives prominence to the following departments of a Water-Works System:

DAMS
AQUEDUCTS
PUMPING STATIONS
PIPE SYSTEMS
WATER TOWERS
FILTERS

SAMPLE COPIES FREE

Subscription Price, $3.00 a Year

ENGINEERING RECORD

239 WEST 39TH STREET NEW YORK

CLASSIFIED DIRECTORY OF ADVERTISEMENTS (*Concluded*).

PAGE.

LEADITE.
The Leadite Co. . . . xxvi

METERS.
Buffalo Meter Co. . . . ix
Builders Iron Foundry . . . xi
Hersey M'f'g Co. . . . iv
National Meter Co. . . . ii
Neptune Meter Co. . . . vi
Pitometer Co. . . . x
Pittsburg Meter Co. . . . vii
Thomson Meter Co. . . . v
Union Water Meter Co. . . . x
Henry R. Worthington . . . viii

METER BOXES.
Clarke, H. W. Co. . . . xii
Hersey M'f'g Co. . . . iv

OIL, GREASE, ETC.
Jos. Dixon Crucible Co. . . . xii

PIPE JOINTS.
The Leadite Co. . . . xxvi

PRESSURE REGULATORS.
H. Mueller Mfg. Co. . . . xiv
Ross Valve M'f'g Co. . . . xv
Union Water Meter Co. . . . x

PUMPS AND PUMPING ENGINES.
Builders Iron Foundry . . . xi
National Meter Co. . . . iii
R. D. Wood & Co. . . . xvi

REINFORCED CONCRETE PIPE.
Lock Joint Pipe Co. . . . xxvii

TAPPING MACHINES.
Hays Mfg. Co. . . . xiii
H. Mueller Mfg. Co. . . . xiv
The A. P. Smith M'f'g Co. . . . xxiii
Water Works Equipment Co. . . . xxv

TOOLS AND SUPPLIES.
H. Mueller Mfg. Co. . . . xiv
The A. P. Smith M'f'g Co. . . . xxiii
Hays M'f'g Co . . . xiii
The Leadite Co. . . . xxvi
Water Works Equipment Co. . . . xxv

NOTICE.

The copies of the September, 1914, Journal have been entirely disposed of. Members who are willing to dispose of their copies will kindly mail them to the Secretary who will pay 75 cents a copy for a limited number. The following Journals are also wanted to make up sets: June, September and December, 1887; September, 1888; June, 1893; March and September, 1899; and September, 1905.

New Members!

Order your certificate of membership and the Association button Now.

New England Water Works Association

STANDARD SPECIFICATIONS

FOR

Cast Iron Pipe

AND

Special Castings

Price 10 Cents

Address, WILLARD KENT, *Secretary*
715 Tremont Temple
BOSTON, MASS.

WILLARD KENT, *Sec'y,*
715 Tremont Temple,
Boston, Mass.

Dear Sir:

Enclosed please find $ .75 / 1.50 / 2.25 in payment of charge for Certificate of Membership in the N. E. W. W. Association ($1.50), and Membership Button ($ .75), which please mail me and oblige

Yours truly,

_____

_____

New England Water Works Association,

ORGANIZED JUNE 12, 1882.

APPLICATION FOR MEMBERSHIP.

I, the undersigned, residing at .....

..... *being desirous of admission into the New England Water Works Association, hereby make application for* .....
(resident, non-resident or associate)

.....*membership.*

I am .....*years of age, and I have been engaged in the following named work:*

.....

.....

.....

I will conform to the requirements of membership if elected.

Signed, ...

Address, ...

Dated, ...*191*

Resident members are those residing in New England; all others are non-resident.
Entrance fee is $5.00 for resident and $3.00 for non-resident members.
Annual dues are $3.00 for both resident and non-resident members.

Endorsed by

.....

.....

Members N. E. W. W. Association.